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REPORT OF THE JOINT INDUSTRY - DOD TASK FORCE ON  
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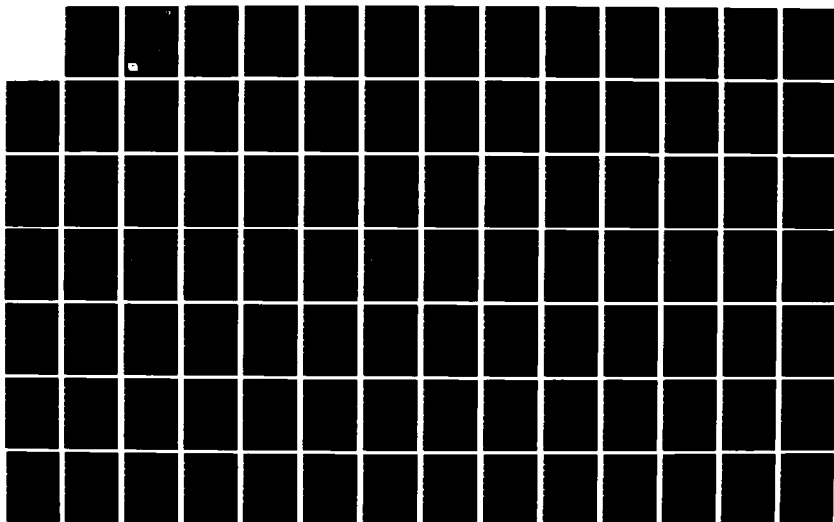
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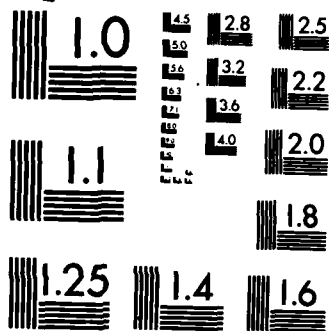
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IDA REPORT R-285

REPORT OF THE JOINT INDUSTRY - DoD TASK FORCE ON  
COMPUTER AIDED LOGISTIC SUPPORT (CALS)

Volume III: Report of Architecture Subgroup

Frederick R. Riddell  
Richard A. Gunkel  
George Beiser  
Siegfried Goldstein  
Bruce Lepisto  
*Editors*

June 1985

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*Prepared for*  
Assistant Secretary of Defense  
Manpower, Installations and Logistics

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) In April 1984 the Institute for Defense Analyses was directed by OSD to assemble a task force of senior industry and government people to address the problems faced by DoD in attaining an integrated computer-aided logistics support system. The task force was given a charter to "develop a strategy and a recommended master plan for computer-aided (continued)						
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logistic support." The task force was formed and held an intensive series of meetings during the last half of 1984 during which this report was prepared.

Volume I of the report gives a summary of the task force deliberations and lays out a recommended strategy and master plan that would, in five years, have in place all the elements needed for a complete computer-aided logistics support (CALS) system based on electronic data transfer. Volumes II, III, IV and V of the report were prepared by the subgroups that were formed to examine different aspects of implementing a CALS system. These volumes contain detailed information that supports the recommendations made in the Summary, Volume I.

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June 1985

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## PREFACE

This report was prepared by the Institute for Defense Analyses (IDA) for the Office of the Secretary of Defense, Manpower, Reserve Affairs and Logistics Under Contract Number MDA 903 84 C 0031, Task Order T-3-192, "R&D Support to Improve Force Readiness."

The issuance of the report answers the specific task to "...assemble a group of both industry and government personnel...experienced in...computer-aided technologies for automation of support procedures in order to examine issues...include(ing) the subcontractor level, inventory management techniques, etc. At present these issues are being addressed individually without apparent consideration of their interaction in meeting the total DoD objective...to evolve a general plan for automated support of DoD operating systems which addresses the problems of interaction between the different systems now in use or evolving, and the various approaches being taken by DoD to address its readiness problems."



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## ARCHITECTURE SUBGROUP MEMBERS

### 1. SUBGROUP COMPOSITION

Chairman: John Barker  
Vice-Chairman: Oscar Goldfarb  
Integration: Dick Alweil  
DoD/IDA: Siegfried Goldstein

Members: Tom Bahan  
Nick Bernstein  
Rich Callan  
Judson French  
Bill Gorham  
Alan Herner  
Mark Pittenger  
Don Tetmeyer

### 2. PRIME RESPONSIBILITIES

IDEF Charts: Bernstein, French

#### a. Industry

Logistics Management (A1)	Goldstein
Influence Design/Modification (A2)	Goldstein
Contractor Support (A31)	French
Training (A32)	Alweil
Maintenance and Operation Data (A33)	Pittenger
Test and Evaluation (A34)	Gorham
Manufacture (A35)	Bernstein
Logistics System (A36)	Pittenger

#### b. Government

Support Acquisition and Management (A1)	Gorham
Training (A3)	Bernstein
Maintenance (A3)	Tetmeyer
Modification (A4)	Callan
Test and Evaluation (A5)	Gorham
Supply Support (A6)	Pittenger

c. **Demonstrations**

#1	Digital Delivery of Technical Publications	Pittenger
#2	Interactive Diagnostics and Maintenance Aids	Tetmeyer
#3	Reliability and Maintainability in Computer-Aided Design	Herner
#4	Interactive LSAR	Herner
#5	Automation of Classic Logistics Data Item	Goldstein
#6	Computer-Aided Classic Specification/RFP Preparation	Goldstein
#7	Integration of Demonstration Projects	Bahan

## **Volume III ARCHITECTURE SUBGROUP REPORT**

### **SECTION I: INTRODUCTION**

#### **A. INTRODUCTION**

This volume is intended to document the efforts, findings, and recommendations of the Architecture Subgroup of the CALS Ad Hoc Group.

This subgroup was chartered to provide an architectural framework for a CALS system that would allow DoD to make full use of contractor-generated digital data, and to determine implementation considerations for the near term (the next 5 years) and longer term (10-15 years) timeframes to achieve this objective.

#### **B. ARCHITECTURE SUBGROUP APPROACH**

The Subgroup began its efforts by evaluating <sup>the various interpretations</sup> the various interpretations of an "architecture" (data flow, hardware, software, system, geographical, organizational, etc.) which could be used to characterize the CALS system.

The architecture was viewed as serving several purposes:

- a. To provide the "system" concept to tie together the many diverse considerations involved in such a very large integration effort.
- b. To scope the CALS system and its functions ~~for the Ad Hoc Group~~ so as to focus the efforts of the other subgroups (Technical Issues, Data Requirements, and Policy/Legal Issues).
- c. To provide an initial foundation upon which the further development and implementation of the target system could rest.
- d. To describe the target system in such a way that it could be readily understood and acted upon by government and industry.

The Subgroup decided that these purposes could be best realized in the time allotted by developing a functional description of CALS which could later be refined and expanded into the needed architectures. It was further decided that this description should be in terms of the types of information which are, or should be, associated with each CALS function, and the computerization of the generation, modification, storage, retrieval, distribution, and use of that information.

### **1. CALS Functions and Information**

In order to define the boundaries of CALS, the Subgroup developed a list of CALS functions and associated data types for the desired target system. The list was divided into two parts: Contractor Functions; DoD Functions (see Section II, Tables II-1 and II-2). These lists then became the de facto definition of the functions within the CALS purview. As discussed in this volume, the data types associated with each function are broad, generic classes of information produced or utilized in the performance of each function.

### **2. CALS Issues Matrix**

Major CALS issues identified by the Architecture Subgroup were discussed and tabulated. They were then reviewed to note which subgroups might appropriately address each issue and distributed accordingly. The matrix of issues is shown in Table I-1.

### **3. Functional Description of Target System**

To produce an adequate functional description of the target system concept, several complementary descriptive elements were selected, and assignments to produce them were accepted by Subgroup members. They were as follows:

- Concept Papers - describing the ways in which selected logistics functions will be performed in their computerized implementation in 10 to 15 years, and identifying implementation considerations and likely payoffs.
- A Graphical Mode/Representation - of target system functions, relationships and information flows.
- Narrative Descriptions - of the graphical model elements, giving the status of the existing implementations, the target system characteristics, the benefits of automating, integrating, standardizing, etc., anticipated problems, projected solutions, and rough qualitative estimates of implementation costs.

Modeling techniques and languages to represent the relationships between functions and the concomitant flow of information were investigated and presented. The ICAM Definition Language (IDEF<sub>0</sub>) Functional Model was selected as the best approach for several reasons: its hierarchical structure allowed the Subgroup to use a top-down approach and add detail as time permitted; several Subgroup participants were familiar with IDEF so that outside expertise was not required; and support was available to computerize the "model," allowing for rapid additions and modifications. A brief description of the IDEF<sub>0</sub> methodology is given in Section C.

**Table I-1. CALS ISSUE MATRIX**

Issue	Group Assignment	Architecture Issues Priorities
1. Who will maintain data? Industry? DoD?	Data/Policy	
2. Specs/Standards <ul style="list-style-type: none"> <li>• Delivery Formats</li> <li>• Data Base</li> <li>• Interface</li> <li>• Communications</li> <li>• New Requirements</li> <li>• Changes Required</li> <li>• CALS System Design</li> </ul>	Architecture Technology	1
3. What organizational changes are necessary? <ul style="list-style-type: none"> <li>• DoD</li> <li>• Services</li> <li>• Industry</li> </ul>	Policy	
4. What are desirable system design characteristics? <ul style="list-style-type: none"> <li>• Security</li> <li>• Hardware Independence</li> <li>• Survivability</li> </ul>	Architecture	2
5. How should information products be specified? <ul style="list-style-type: none"> <li>• What MIL SPECS must change to make this happen?</li> <li>• What new SPECS must be prepared for new forms of data delivery (i.e., maintenance aiding software?)</li> </ul>	Data	
6. How will delivered data be employed? (What functions?)	Data	
7. How will DoD enforce/validate/implement the standards?	Policy	
8. What common tri-Service system should evolve?	Architecture	3

(Continued)

NOTE: Priority 1 - Essential  
2 - Desirable  
3 - Least Essential

**Table I-1. CALS ISSUE MATRIX (Continued)**

Issue	Group Assignment	Architecture Issues Priorities
9. How will the CALS system be partitioned into manageable subsystems? • By Data • By Functions • By Process	Architecture Technology	1
10. How to determine which existing CALS should be • Retained • Modified • Replaced • Eliminated	Architecture Policy	3
11. How should the CALS be structured to accommodate the desired enhancement in the design process? (Maintainability, Diagnostics, Embedded Maintenance and Training)	Architecture	1
12. How should DoD incentivize the changes in the design process?	Policy	
13. How will configuration control be implemented within the CALS?	Technology	
14. How should CALS be structured to enhance the effectiveness of: • Training • Maintenance • Re-procurement • Post-production • Support	Architecture	1
15. Is a total paperless system a desired objective? If not, to what extent?	Architecture Policy	3
16. Which subsystems or functions should be computerized?	Architecture	3

NOTE: Priority   1 - Essential  
                   2 - Desirable  
                   3 - Least Essential

(Continued)

**Table I-1. CALS ISSUE MATRIX (Concluded)**

Issue	Group Assignment	Architecture Issues Priorities
17. How should archiving be accomplished? <ul style="list-style-type: none"> <li>• What Data</li> <li>• How Long</li> <li>• What Medium</li> <li>• Disaster Protection</li> </ul>	Technology Data	
18. How can the Government logistics data be accessed through CALS? (Standard Parts, Inventory, Field Experience)	Technology Policy	
19. What additional data should the Government collect and supply?	Data	
20. Who within DoD will be responsible for implementing CALS?	Policy	
21. What vehicles should the DoD employ to advance the identified technology?	Policy	

NOTE: Priority 1 - Essential  
 2 - Desirable  
 3 - Least Essential



From the knowledge and information obtained while developing these output products, the Subgroup was then able to assemble a series of recommendations and devise appropriate demonstration projects to carry those recommendations into working systems. These recommendations and demonstration projects appear in Sections III and IV, respectively.

Time did not permit concept papers or IDEF representations to be produced for all CALS functions. Those that were completed appear in Section II by function in the following order:

- Top Level IDEF Function Chart
- Concept Paper or Narrative Description
- Lower Level IDEF Charts
- IDEF Narrative.

## **C. EXPLANATION OF THE IDEF METHODOLOGY**

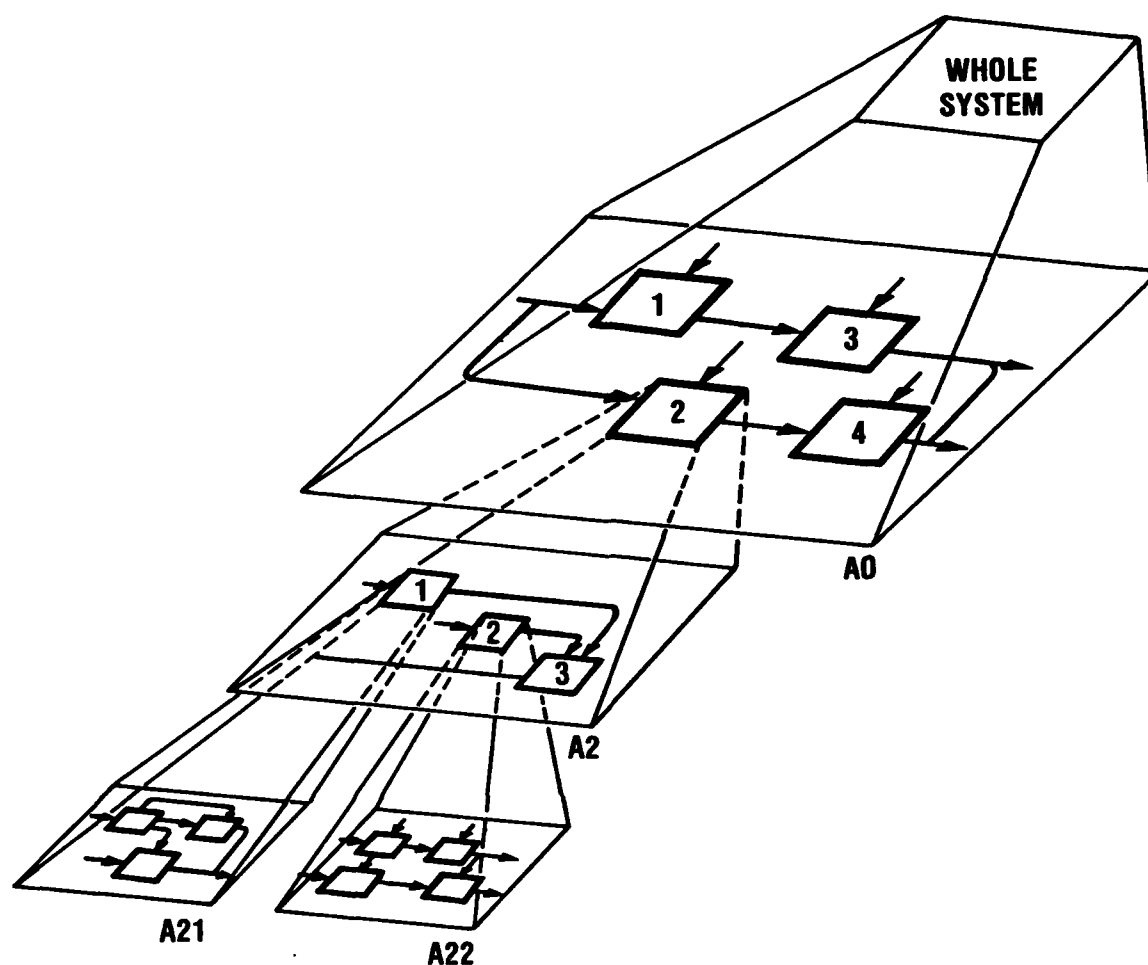
### **1. Overview**

The IDEF<sub>O</sub> or functional model of the architecture is the structured approach employed to achieve program definition of subsystems and systems as well as a generic representation of Computer-Aided Logistics Support (CALS).

The brief explanation that follows is designed to acquaint someone having no prior exposure to IDEF<sub>O</sub> with its methodology and provide them with sufficient information to read and understand IDEF<sub>O</sub> models.

### **2. Description**

IDEF<sub>O</sub> is a structured approach to produce complete program definition. This "top-down" approach can be visualized as an expanding pyramid structure (see Figure I-1). A function at the top can be decomposed into a number of subfunctions; in this case, the "A-ZERO" function consists of four subfunctions. Any of these subfunctions can be further decomposed, as shown by subfunction box A-2, which breaks down into three lower level functions, A-21, A-22, A-23. These functions are then separated into distinct steps as shown by function A-21 breaking down into three lower functions and function A-22 breaking down into four lower functions; A-23 has no lower function. The process is continued until the architect of the model achieves the level of understanding he requires.



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**Figure I-1. ARCHITECTURAL BASIS OF CALS TOP-DOWN DESIGN**

This "top-down" approach is necessary to obtain complete program definition with all functions described at their proper level in the hierarchy. At this point one can choose a collection of steps, operations or functions and build a (computer) system to support the model, or simulate its behavior.

The structured approach assures proper consideration of all constraints and interfaces of the model. Developments then utilize a "bottom-up" construction approach. The modeling assures that these developments will be upward-compatible, i.e., they will INTEGRATE.

### 3. Methodology

In building an IDEF<sub>0</sub> (functional) model, the system is viewed as a collection of diagrams composed simply of labeled rectangular boxes with interfaces identified by directed lines (arrows) (see Figure I-2). The boxes represent activities and the arrows represent "objects" processed by the system. By "objects" are meant any substantive noun item ranging from tangible objects to abstract information. The activity in a box can be anything denotable by an active verb, whether a concrete or a conceptual action. Examples include "tighten," "attach," "measure," "assemble," "classify," "construct," "solve," "adapt," "consider," "develop," etc. Activities do not include functions expressed as nouns, such as "maintenance," nor are they passive in form. The arrows represent objects or anything describable by a noun phrase.

The Functional Model, then, is a collection of activity diagrams that decompose a complex operation or subject into its component parts. The initial diagram is the most general or abstract description of the entire system. This diagram shows each major component as a box. The details -- or "insides" -- of every component "box" are shown on other diagrams at a lower hierarchical level. These lower ranking diagrams also show their components as even lower-ranking boxes -- and so on to any desired level of detail.

Each detailed diagram presents a finer description of just one box on its "parent" diagram (see Figure I-3). Arrows entering and leaving the parent box are exactly those in the "child" diagram. The activity verb in a "parent box" is always a broader, more generalized term than those identifying boxes in successively lower diagrams.

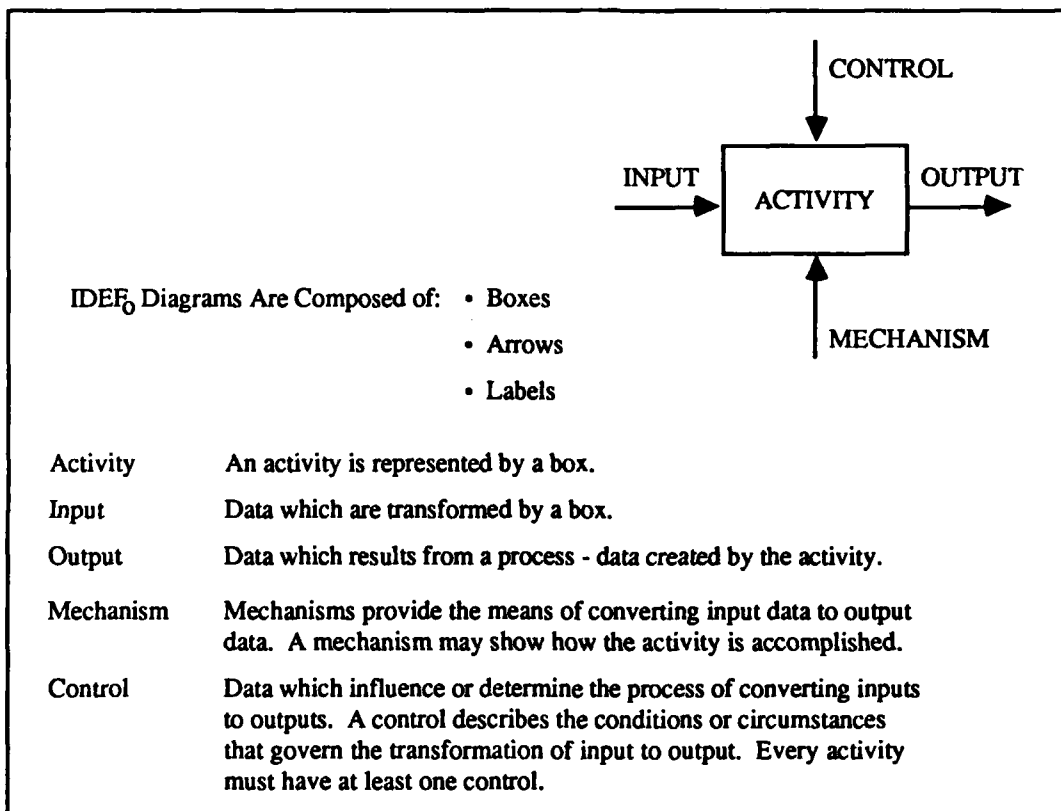


Figure I-2. IDEF<sub>0</sub> LANGUAGE FUNDAMENTALS

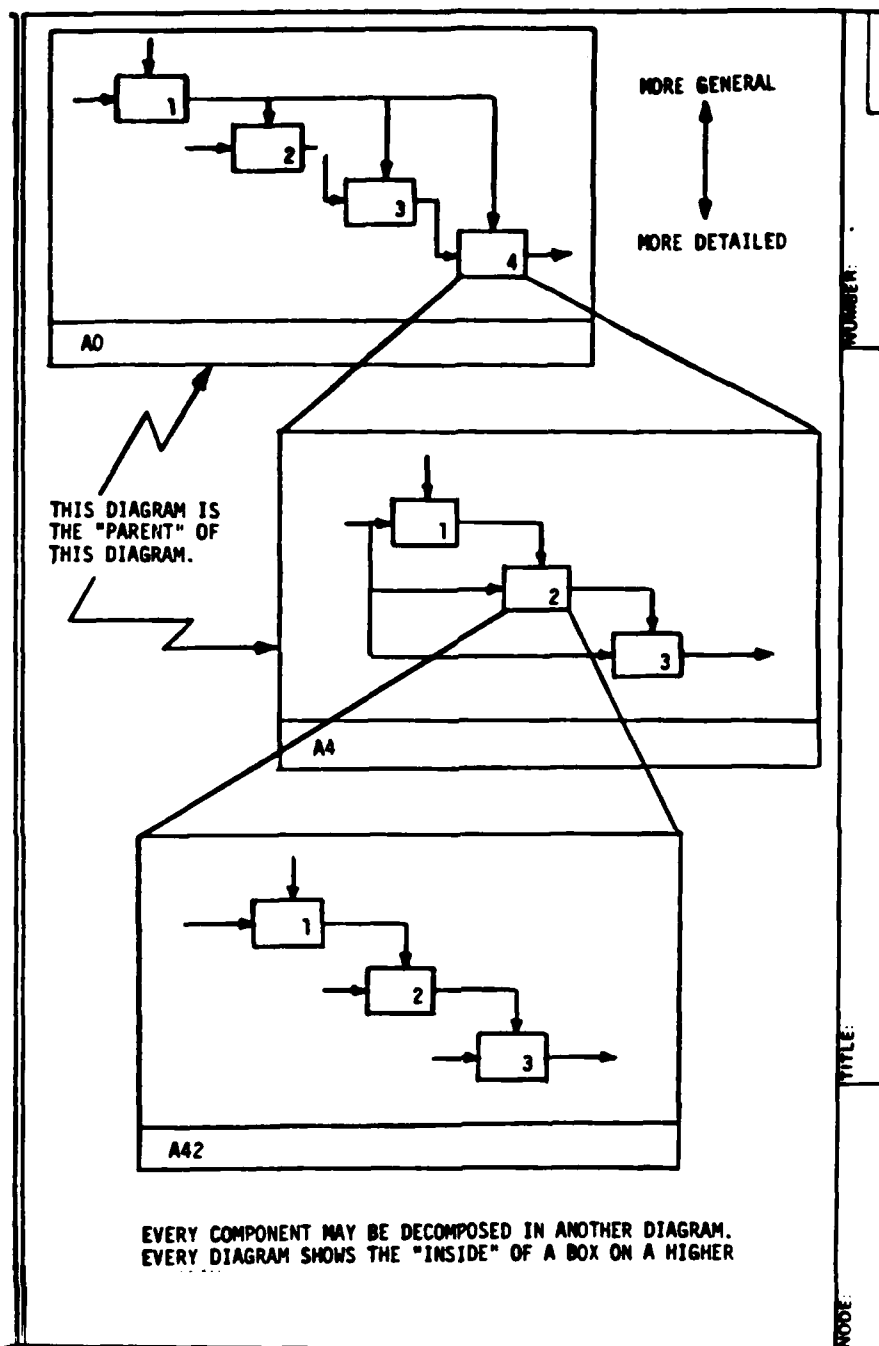


Figure I-3. IDEF DIAGRAMMING HIERARCHY

## **SECTION II: SYSTEMS CONCEPT OVERVIEW**

### **A. INTRODUCTION**

Tables II-1 and II-2, respectively, delineate the list of CALS functions and associated data types for Contractor Functions and DoD Functions. The data types associated with each function are broad generic classes of information produced or utilized in the performance of each function.

Annex 1 to this volume supports Table II-1 in providing working papers and briefing reports documenting CALS Contractor Functions. Annex 2 documents CALS DoD Functions. Both annexes can be found at the back of this volume.

**Table II-1. IDEF BREAKDOWN STRUCTURE FOR  
CALS CONTRACTOR FUNCTIONS, AO**

<b>AO</b>	<b>PROVIDE CALS, CONTRACTOR FUNCTIONS</b>
<b>A1</b>	<b>PERFORM LOGISTICS MANAGEMENT</b>
A11	Provide Configuration Management
A12	Provide Cost and Schedule Control
A121	Provide Cost Control
A122	Provide Schedule Control
A13	Manage Support Resources
<b>A2</b>	<b>INFLUENCE DESIGN/MODIFICATION</b>
A21	Provide Design Guidance
A22	Perform Allocations
A221	Initiate Diagnostic Procedure
A222	Partition Equipment
A223	Establish Reliability Allocation
A224	Conduct Trades
A225	Maintainability Allocations
A226	Provide First Cut Failure Mode Effects and Criticality Analysis
A23	Perform Equipment Design
A24	Perform Analyses
A241	Perform Reliability Stress Analyses
A242	Perform Testability Analyses
A243	Perform FMECA
A244	Perform Transportability and Repair Level Analyses
A245	Perform Maintainability Analyses
A246	Perform Human Factors and Safety Analyses
A25	Support Trades
A251	Perform Repair Level Analysis
A26	Demonstrate and Approve
A261	Develop Procedures
A262	Perform Valications/Demos: Reliability Maintainability Supportability
A263	Assimilate Analyses Results

(Continued)

**Table II-1. IDEF BREAKDOWN STRUCTURE FOR  
CALS CONTRACTOR FUNCTIONS, AO (Concluded)**

<b>A3</b>	<b>PROVIDE LOGISTICS RESOURCES</b>
A31	Provide Contractor Field Support
A311	Provide Trained Contractor Personnel
A312	Accomplish Site Activation
A313	Provide Depot Support/Operation
A314	Provide Production/Post-Production Support
	A3141 Provide Maintenance Service Information
	A3142 Perform Maintenance
	A3143 Provide System Specific Expertise
A321	Define and Acquire Training Equipment
A322	Develop Courses
A323	Conduct Training for Government Personnel
A33	Prepare Maintenance and Operation Data
A331	Develop/Update Maintenance and Operation Data
A332	Validate/Verify Maintenance and Operation Data
A333	Deliver/Archive Maintenance and Operation Data
A34	Perform Test and Evaluation
A341	Plan Test
A342	Conduct Test Program
A343	Evaluate Test Data/Results
A35	Perform Manufacture
A351	Plan for Manufacture
A352	Make and Administer Schedules and Budgets
A353	Plan Production
A354	Provide Production Resources
A355	Obtain Manufacturing Materials
A36	Provide Logistics Systems
A361	Develop Support System
A362	Prepare Logistic Support Analysis Record
A363	Develop Support Equipment Specifications
A364	Develop Facilities Design Criteria
A365	Plan Transportability
A366	Develop Instructional System



**Table II-2. IDEF BREAKDOWN STRUCTURE FOR  
CALS DoD FUNCTION, AO**

<b>AO</b>	<b>PROVIDE CALS, DoD FUNCTION</b>
<b>A1</b>	<b>PROVIDE SUPPORT ACQUISITION AND MANAGEMENT</b>
A11	Perform Configuration Management
A111	Establish Configuration Baseline
A112	Provide Configuration Control
A113	Implement Logistics Support Analysis
A12	Perform System Life Cycle Management
A121	Conduct Logistics Support Planning
A122	Conduct Support System Acquisition
A123	Manage Deployed Systems Support
A13	Perform Resource Planning
A14	Provide Support Acquisition
A15	Accomplish Site Activation
<b>A2</b>	<b>PROVIDE TRAINING</b>
A121	Define and Acquire Training Equipment
A122	Develop Courses
A123	Conduct Training
<b>A3</b>	<b>PERFORM MAINTENANCE</b>
A31	Provide Maintenance Management
A32	Inspect/Diagnose Failure
A33	Perform Repair and Check (Any Level)
A34	Perform Overhaul
A35	Record Maintenance Action Data
A36	Perform Failure Analysis
<b>A4</b>	<b>PERFORM MODIFICATION</b>
A41	Generate Redesign Requirement
A42	Redesign Item
A43	Remanufacture Item (Contractor/Depot)
A44	Perform Field Modification (DS/GS/Depot)
<b>A5</b>	<b>PERFORM TEST AND EVALUATION</b>
A51	Plan Test Program
A52	Conduct Test Program
A53	Evaluate Test Data/Results
<b>A6</b>	<b>PROVIDE SUPPLY SUPPORT</b>
A61	Perform Inventory Management
A62	Acquire Material
A63	Store and Distribution

### **SECTION III. CONSOLIDATED RECOMMENDATIONS**

#### **A. OVERVIEW**

The recommendations contained in this section represent the major concerns of the Architecture Subgroup in making CALS a reality. The order of presentation has no bearing on the importance of the recommendation on that objective, but rather on the timing and ease of implementation, given the state-of-the-art today. However, all of the recommended actions are required, at least to some degree, to ensure implementation and utilization of CALS.

If one were to attempt to rank the recommendations in order of importance to the objectives to improve readiness and sustainability by taking advantage of computer-aided design, drafting and manufacturing, the order would be:

- Incentivize industry to move forward with the design-influencing issues of CALS.
- Motivate, educate and direct the Government agencies to make maximum use of CALS.
- Resolve the data item issues.

The recommendations conclude that specific details of action within these recommendations must be developed. To do that, specific areas need to be expanded by the CALS Ad Hoc Group, work statements prepared, and outside activities monitored and guided. All these are activities that should be started if the recommended actions were accepted, and will therefore require that certain, specific group activities be continued, as discussed in the paragraphs that follow.

#### **B. SPECIFIC RECOMMENDATIONS**

##### **1. Recommended Logistics Data Item Consolidation Techniques With LSAR**

###### **a. Approach**

Given the traditional reluctance of DoD's functional logistics personnel to deviate from the classic, hard-copy data item requirements (DIDs) for specific deliverable formats, and the fact that present contracts and RFPs require both the classic formats and duplicative LSAR outputs to be delivered, the following approach to near-term (within 3 years) integration of MIL-STD-1388's LSAR requirements with those of other support-related

DIDs is recommended. This approach will minimize the organizational and cultural impact of the transition from standard DIDs to digitized data/information transfer upon the Services. At the same time it will reap the benefits of an integrated data source (prepared from the "standard and Neutral Formats"), common audit trail, common configuration control, and standardized Service/industry interfaces.

The recommendation is to initiate a funded task to develop the capability to produce the full range of logistics data items (DIDs) from the LSAR data base and demonstrate the feasibility of on-line terminal delivery of data normally delivered in hard-copy DID formats. Development of the capability to produce support-related DIDs from the LSAR should proceed as follows:

- a. Conduct a study to identify the data elements required to produce the classic logistics data items (including, but not limited to, GSERD, CMRS, Task and Skills Analysis, Technical Publications, Provisioning Technical Documentation, Illustrated Parts Breakdowns and R&M analysis data, etc.) which are not contained in the LSAR data element dictionary.
- b. Develop the software necessary to process the additional data elements identified in (a) above and produce the classic logistics data items from the LSAR data files. Demonstrate the use of this software in a realistic logistics planning environment.
- c. Incorporate the additional data elements identified in (a) above into MIL-STD-1388 and upgrade the DoD LSAR ADP system to include the capabilities demonstrated in (b) above.

**b. Parallel Effort**

In parallel with the effort discussed above, initiate an effort to demonstrate the benefits of on-line logistics data delivery to the user of those data. This effort should be conducted as follows:

- a. Select a weapons system or system modification program that will generate requirements for a large quantity of some logistics data item (such as Ground Support Equipment Recommendation Data).
- b. Produce and deliver the required data items in the specified classic, hard-copy form as prepared from the LSAR data base.
- c. Simultaneous with (b), implement the capability for user(s) to retrieve needed data from an on-line data system through the use of terminals located in their work area.
- d. Record and document the relative utilization of the hard-copy deliverables and the advantages of on-line terminals delivery.
- e. Based upon the results of (d), develop specification changes to require industry and DoD components to move away from classic logistics data items and towards on-line data retrieval, primarily from LSAR.

This task should be initiated as soon as possible, preferably during 1985, and should be chartered at the DoD level.

**2. Outputs of CALS Demonstration Efforts**

All CALS demonstration efforts should result in capabilities that can be embodied in appropriate standards and data item descriptions for implementation throughout DoD. Each demonstration effort should result in drafts of the standards and DIDs that are appropriate to its activities.

**3. Demonstrate the Digital Delivery of Technical Publications**

Technology is available to provide multi-Service electronic delivery formats for technical publications. Integration of publications requirements with LSAR, provisioning technical documentation and integration of the data with CAE/CAD should be accomplished to minimize the number of interfaces and consequent translating techniques that industry and DoD must maintain for data delivery. Development of multi-Service electronic delivery formats will reduce the number of translators and delivery formats required by both industry and the Services. This activity will also be a precursor for delivery of publications data via interactive maintenance aids.

**4. Development of Configuration Control Strategy for Electronic Data Systems**

CALS should be structured to allow simple tracking of configuration management data by electronic systems. The development of engineering and CAD/CAM systems will include methods of controlling and documenting equipment configuration. CALS must be structured to utilize this configuration data and be expanded to track and control the configuration of logistics data and support resource elements and to match these to the operational and maintenance hardware/software.

**5. Development of Incentives for Both DoD and Industry to Move Forward With CALS**

Both industry and DoD (government agencies) need solid reasons for adopting the changes that will be required to fully utilize and take advantage of CALS. Its adoption, though doubtlessly very beneficial in the long run, will be costly, inconvenient and resented by some whose way of doing business will be upset. The considerations and attendant recommendations are as follows:

#### **a. Industry Incentives**

Because industry is profit-oriented, recommendations must ultimately result in profit. To the contrary, it will result in less absolute dollar value profit, since a percentage of less cost (profit) is a lesser amount of money. Therefore, the incentive issue is not that simple, and will require some development. Issues that should be considered are the Win-Lose Issue and the Reduction of Waste Issue.

**The Win or Lose Issue.** The RFP is a powerful profit incentive, since loss of an opportunity for work is total loss of profit. To use it to the proper advantage, the government must learn to:

- (1) Prepare specification requirements in such a way that the R,M&L design attributes are unmistakably spelled out in terms that a design engineer can understand and relate to.
- (2) Prepare quality assurance requirements in such a way that design proof by analyses can only be performed by computerized techniques. This will force their use in the design process as well.
- (3) Prepare quality assurance requirements in such a way that test and evaluation must make maximum use of automatically developed test procedures, which must be updated as a result of these tests, and then be required to be employed in production acceptance testing.

**The Reduction of Waste Issue.** In contracts that have already been let as well as add-ons and sole-source contracts, there is no "win-or-lose" issue. Instead there is the threat of profit erosion due to unexpected problems, overruns from difficult/expensive data item preparation, and costly redesign due to failure to meet requirements as identified in analyses and/or tests. Here incentives will consist of:

- (1) Improved productivity in data preparation.
- (2) Timely analyses to identify problems and ensure that designs can meet requirements before the designs are committed to drawings and manufacture.
- (3) Reduction in manpower, particularly hard to find "illities" expertise.

Preparation of these incentives will require proof that the computerized techniques will provide the above benefits. Credible before-and-after statistics will need to be developed and presented to industry.

### **b. Government Agencies Incentives**

Unlike industry, government agencies do not work on profit; rather, they require budget and a set level of staff. Staff reduction for the agencies is not necessarily an incentive; nor is re-organization. Therefore, incentive plans must be developed to work within the framework of organizations, yet make these organizations more effective, reduce the workloads, and provide for more accurate results.

It should be noted that if the users do not adopt, or take advantage of, industry's modernization along the lines of CALS, the skepticism on the part of industry will grow, as it has in the past, to once again defeat the goals of improved logistics issues.

Directives will be required, as will investments in computers and in solving the standardization issues. One overseeing agency for coordination must be established, and educational programs begun.

### **6. Charter a DoD/Service Group That Will Be Responsible for Developing and Implementing Common Data Delivery Formats for All Services**

To reduce the number (type) of data delivery formats required by the Services, the Demonstration Group should be chartered to review their demonstration projects and implement common data delivery formats for all Services, wherever possible.

In addition, an intra-Service coordination committee should be established, and a chairman and key personnel appointed to perform the following tasks:

- (1) Interact with the other Services, DLA and industry to form an oversight/coordinating committee, and appoint representatives to that committee.
- (2) Define specific plans to implement the following pilot demonstration programs as they relate to each Service:
  - a. Automate supportability design-to-criteria (Performance R,M&L tradeoffs, Safety, and GSE).
  - b. Automate ILS support elements using LSAR, i.e., supply support, support equipment, T.O.s training.
  - c. Automate acquisition of logistic support requirements (contractor to government to contractor).
  - d. Logistic data access and file transfer.
  - e. Data audit/approval techniques.
  - f. Structured data base management system applications to CALS.
- (3) Define action that has already been taken towards the above.

- (4) Prepare a CALS data/information flow chart tailored to each Services' needs, indicating support-related data flows.
- (5) Take an inventory of the digital data transfer techniques already in place.
- (6) Prepare a specific plan to standardize the interfaces between this Service and:
  - a. The contractor
  - b. The other Services
  - c. NATO
  - d. DLA.
- (7) Prepare a plan for:
  - a. Specifying and controlling contractor developed data/information.
  - b. Utilization of these data/information.

**7. Develop Concrete Implementation Plan for Assignment to the DoD/Services Group**

The DoD/Services and DLA should implement an education program to provide people involved in CALS with computer/software knowledge. Technology is progressing very rapidly in the computer sciences and must be understood by planners, managers, implementees and operators to build and keep CALS viable and current with technology.

**8. Assign Responsibility for Continuation of Architecture Development Begun by Architecture Subgroup Using IDEF Techniques**

The overall CALS architecture in the report has only been developed to the higher function levels. The architecture needs to be further defined to the detail levels required by developers and users. The establishment of subgroups to further detail IDEF techniques for this purpose is recommended.

No single set of architectural charts or flow diagrams will reconcile the different (and equally valid) perspectives of all functional specialists. The CALS Architecture Subgroup's IDEF chart is but one model of logistic information flow for defining and demonstrating the CALS study findings and recommendations, beginning the process of establishing a common framework for both industry and DoD to identify and communicate their mutual logistic information requirements. There is a need for improvements in the structured process through which information processing technology is applied to both acquisition and operational logistics management.

It is therefore recommended that the following tasks be continued in greater depth and detail:

- a. Architecture development.
- b. Demonstration planning, scheduling and follow up.
- c. Development of incentives.
- d. Standardization and specification preparation.



## SECTION IV: RECOMMENDED DEMONSTRATIONS

### A. OVERVIEW

This section contains recommended demonstrations to prove the feasibility and cost-effectiveness of CALS elements that are considered essential to the whole of CALS implementation. It may be seen from the following summaries that the demonstrations are essentially horizontal. However, each or all (in some combination) can be employed in the planned vertical demonstrations. Alternately, they can be performed in parallel or ahead of the vertical demonstrations since the resulting techniques and data are essential to the success of the vertical demonstrations. In addition, these demonstrations are short and immediately implementable.

#### 1. Digital Delivery of Technical Publications

Objective: Develop and demonstrate a tri-Service capability to contractually specify and accept delivery of contractor-developed technical publications in a digital format.

Author: Mark Pittenger - Boeing.

#### 2. Interactive Diagnostic and Maintenance Aids

Objective: Demonstrate a capability to design the prime hardware and maintenance-aiding diagnostics as an integrated, interactive system. Present digital maintenance instructions/diagnostics to the technician utilizing a user-friendly, portable display. Show the resulting improvement in maintenance of complex electronic equipment in the field.

Author: Col. Don Tetmeyer - AFHRL.

#### 3. Reliability and Maintainability in Computer-Aided Design (RAMCAD) Demonstration

Objective: Demonstrate and document the benefits of integrating R&M analysis into Computer-Aided Engineering and Design Systems.

Author: Al Herner - AFHRL.

4. **Automated LSAR Input**

**Objective:** Develop and demonstrate a capability to input data automatically to the LSAR. This capability will extract data from the CAD engineering data base and other automated systems and load them directly into the LSAR.

**Author:** Al Herner - AFHRL.

5. **Automation of Classic Logistic Data Item**

**Objective:** Employ computerized techniques to prepare a classic logistic data item (i.e., Support Equipment Recommendation Summary) in its presently specified format directly from an LSAR data base. This will bridge the gap between near term and future data acceptance, while at the same time demonstrate that all duplication of effort between LSAR and the additional data items that are duplicative, but yet are still required by data users, can be eliminated.

**Author:** S. Goldstein.

6. **Computer-Aided Specification/RFP Preparation**

**Objective:** Demonstrate that reliability, maintainability and supportability equipment design attributes can be developed as part of a specification's performance requirements by computer interaction with, and prompting of, the authors. The specification would, as part of an RFP, be sufficiently specific that the appropriate design features would be provided by the designer, taking advantage of the competitive leverage during the proposal phase.

**Author:** S. Goldstein.

7. **Integration of Demonstration Projects**

**Objective:** Demonstrate the ability of the above pilot or prototype systems to interact and communicate so that all logistic functions can be accomplished with standard operating protocols and procedures.

**Author:** Don Bahan - AFALC.

## **B. SPECIFIC RECOMMENDATIONS**

Annex 3 contains the specific recommendations summarized in paragraph A, except Demonstration #7 which involved inputs from the other subgroups and is reported in Volume I, Summary Report, of this series of reports.

## **Annex 1**

### **CALS FUNCTIONAL DESCRIPTIONS CONTRACTOR FUNCTIONS**

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Annex 1

CALS FUNCTIONAL DESCRIPTIONS  
CONTRACTOR FUNCTIONS:

1. General

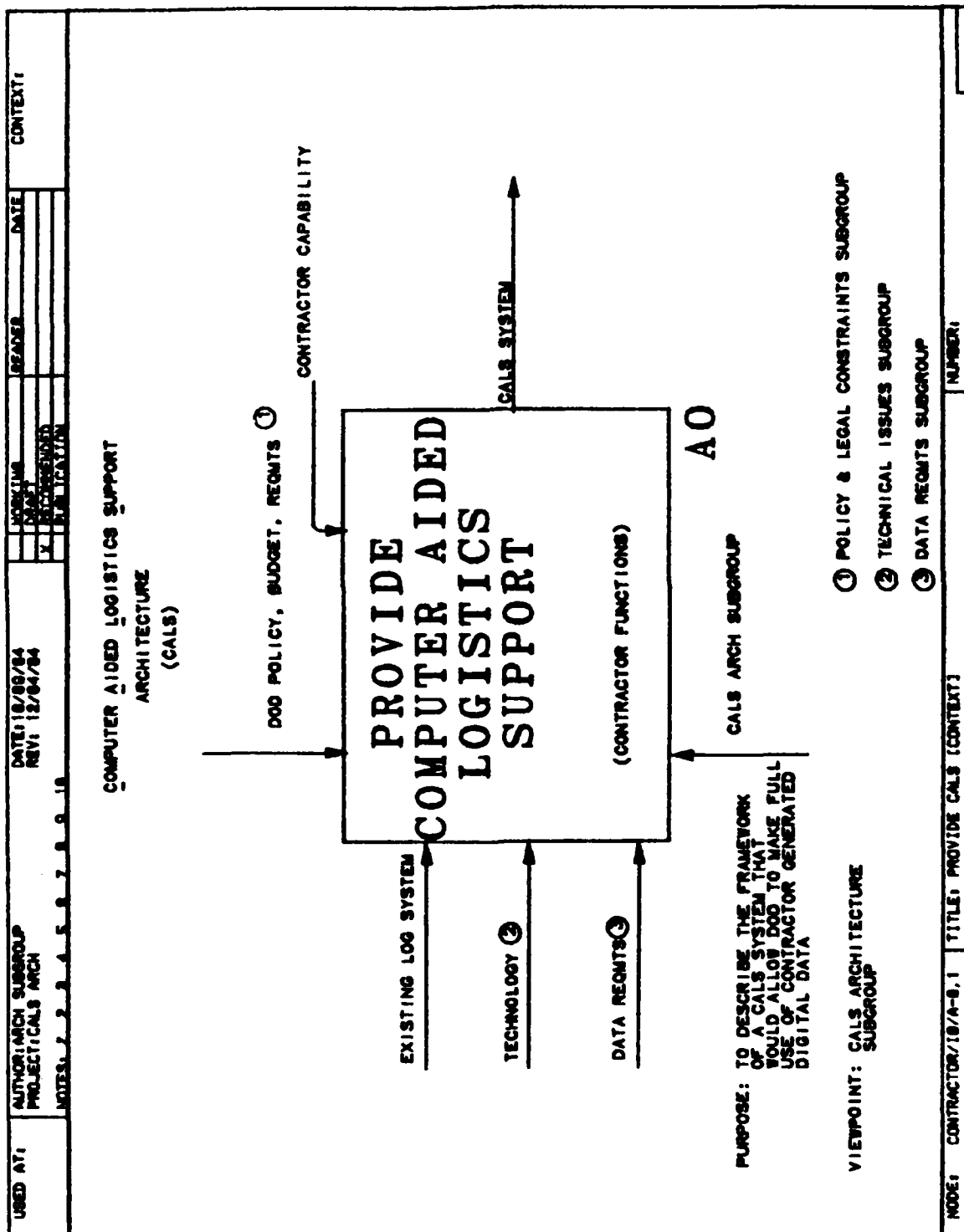


Figure 2-1. IDEF 40, CONTRACTOR

## CONTRACTOR

### A-0 Provide Computer Aided Logistics Support

The purpose is to describe the framework of a Computer Aided Logistics Support (CALS) system that would allow DOD to make full use of contractor generated digital data. The focus as described by the CALS architecture subgroup, is the automation, standardization, and integration of the existing logistics system.

#### Glossary

Existing Log System - An all encompassing term denoting the present way of handling the planning, and data related to the design and acquisition of support resources, primarily hard copy, manually.

Technology - Technical issues related to computerizing all aspects of design influence and logistic support.

Data Requirements - The data and/or information required for design influence and the design, acquisition and preparation of support resources.

DOD Policy, Budget, Reqmts - Constraints placed on the development and implementation of CALS for which the Government is responsible.

Contractor Capability - Constraints placed on the development and implementation for which the contractor is responsible. Primarily computer resources in-place, IR&D investments, technical ability, etc.

CALS Arch Subgroup - The IDA CALS adhoc subgroup assigned to address implementation architecture issues.

CALS System - Computer Aided Logistic Support envisioned as a system concept beginning at the prime equipment design phase and ending at its obsolescence.

A0 Provide CALS (Contractor functions)

Glossary

Data Requirements - That data required by contract.

DOD - Department of Defense.

Contractor - The organization that will perform to the contract.

Technology - Technical issues related to computerizing all aspects of design influence and logistic support.

Design Influence - Affecting the prime equipment's design such that design features to specifically address reliability, maintainability and supportability are included to the extent required to meet or improve contractual requirements.

Existing Log Systems - An all encompassing term denoting the present way of handling the planning, and data related to the design and acquisition of support resources, primarily hard copy, manually.

Resources - Facilities, manpower, capital needed to perform to the contract.



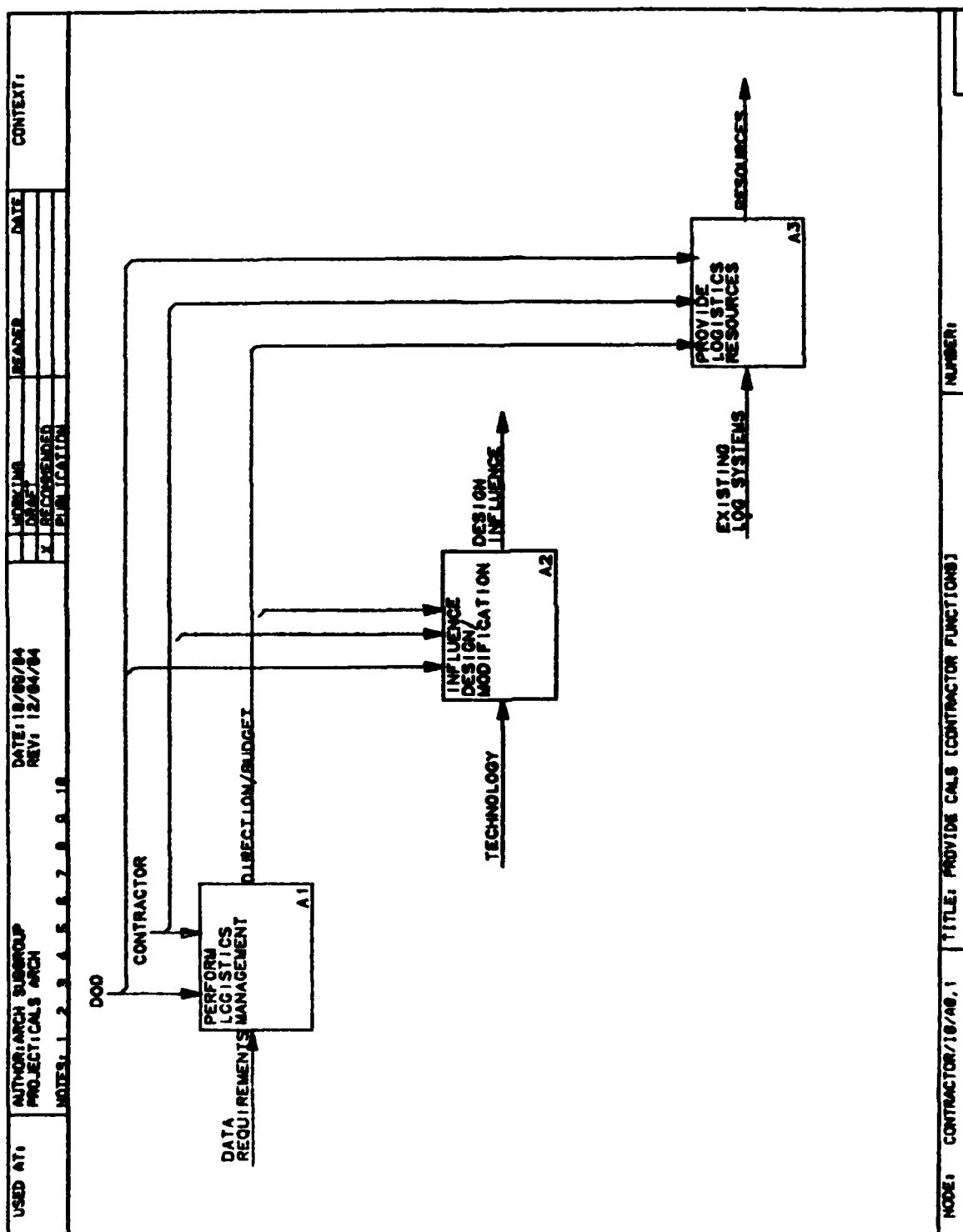


Figure 2-2. IDEF A3, PROVIDE CALS (CONTRACTOR FUNCTIONS)

**CALS FUNCTIONAL DESCRIPTIONS**  
**CONTRACTOR FUNCTIONS:**

**2. IDEF A1, Perform Logistics Management**

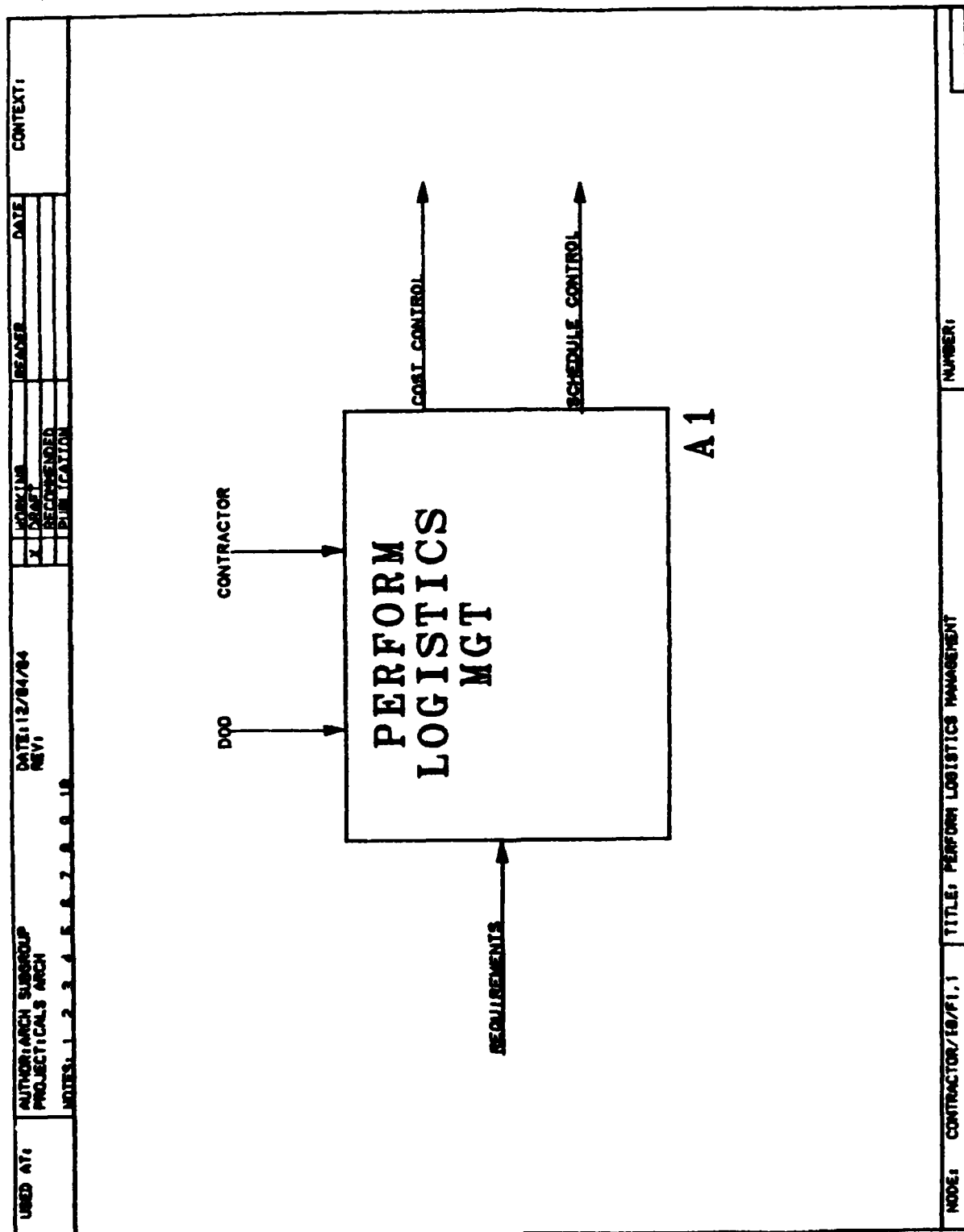


Figure 2-3. IDEF A1, PROVIDE LOGISTICS MANAGEMENT, CONTRACTOR

Table 2-4. IDEF A1, CONTRACTOR

**A1 Perform Logistics Management**

**Glossary**

**Requirements - Identified needs.**

**DOD - Department of Defense.**

**Contractor - The organization that performs work under provisions of a contract.**

**Cost Control - Methodology to manage program costs.**

**Schedule Control - Methodology to manage program schedule.**

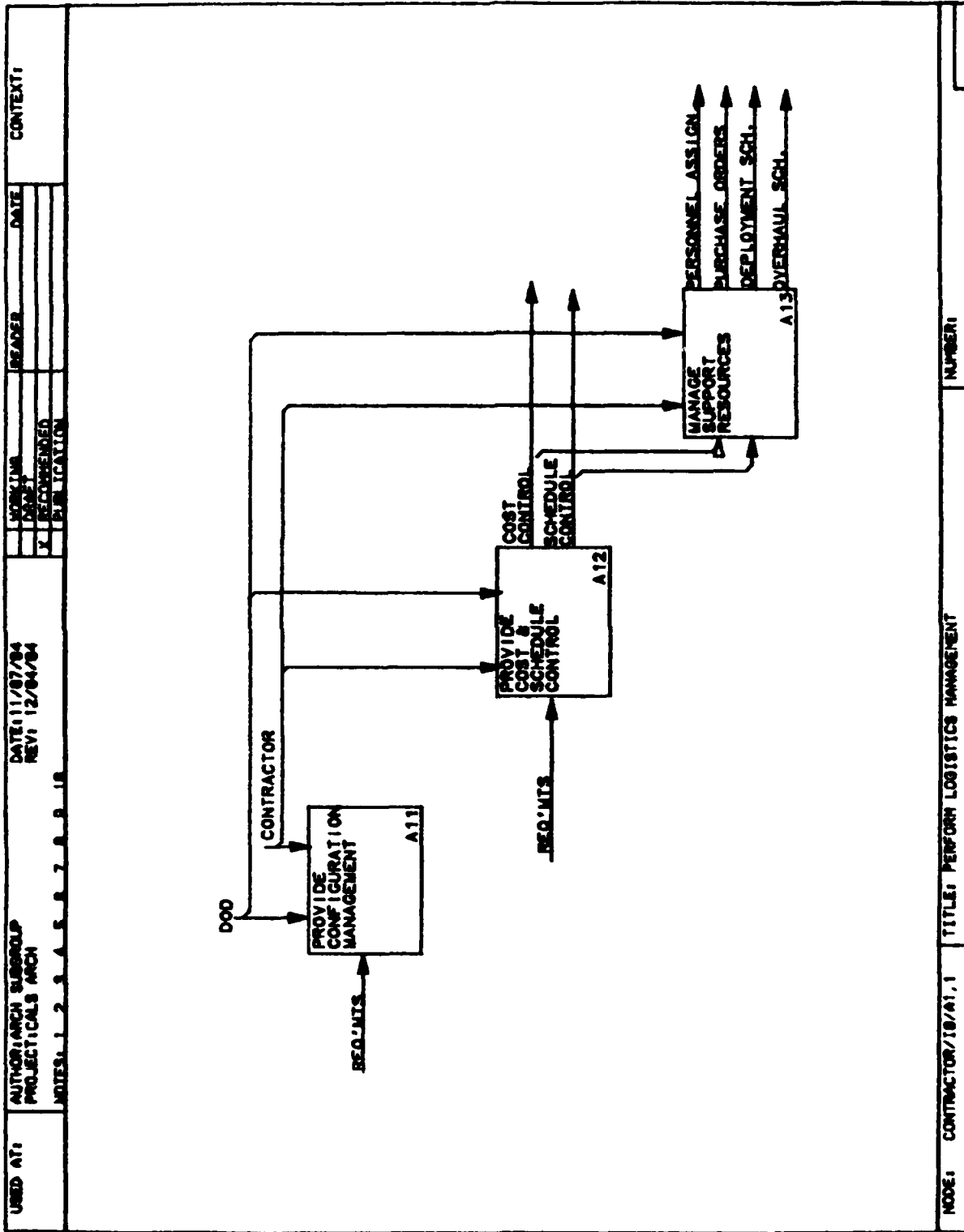


Figure 2-4. IDEF A1, PERFORM LOGISTICS MANAGEMENT, CONTRACTOR

## IDEF A1, CONCEPT PAPER PERFORMING LOGISTICS MANAGEMENT

### 1. FOCUS OF CALS IMPLEMENTATION

1.1 Overview. The logistics functions which start at the time a design is being developed, and end when contractual obligations for the design's support are fulfilled, are the responsibility of a contractor's program/project manager. The specialization of the task usually requires the delegation of that responsibility to an Integrated Logistic Support (ILS) Manager who deals with fulfilling contractual obligations, scheduling, budgeting and integrating and general management of the subtasks (elements) of the logistics program. Large programs may well have managers for each of the subtasks reporting to the ILS manager. They would perform similar duties on a more detailed level. The subtasks divide into two major categories:

a. Categories associated with the equipment design effort. These are engineering and analytical disciplines such as reliability, maintainability, testability, etc., which are discussed under IDEF A2, CALS Influence on Equipment Design.

b. Categories associated with the equipment's support activities and support resources, which are discussed under the several subtopics of IDEF \_\_\_\_, Provide Logistics Support.

The above categories are planning on heavy reliance on CALS for major improvements in performing the many functions of the commensurate tasks themselves, as well as the vital information/data flow between the design, support and field feedback tasks. Proper control, information accuracy and timeliness, as well as traceability and configuration accounting/management is essential to an efficient error-free performance of the tasks described in the A2 and A3 IDEF topics. These discuss heavy reliance on computerized techniques for information/data preparation and configuration management. They

also describe the reliance on a single data base 'system' to ensure proper information/data content and flow.

The ILS manager not only needs to ensure that the process is properly applied and control its application, at least from a top level, but he also needs the tools with which to accomplish this control. Presently this is done with manual or computer-assisted budget and schedule controls, written status reports, etc. At best this is an inefficient process; at worst it does not provide timely status or problem feedback to allow the best management, forward planning and problem work-a-rounds to take place.

**1.2 Projected Performance of the Target System.** The computerized techniques to be employed for utilization for tasks associated with IDEFs A1 and A2 would be interactive with the managerial functions such that an ILS manager, or ILS Element manager could, with proper access authority, receive status of any element of design review/status and support resource planning, acquisition and utilization. He could interact on the line with a computer terminal providing instructions to contractor personnel and providing status and interfacing with the customer/services at the same time. The computerized techniques would assist in schedule preparation and budgeting. Instant forward planning and trades regarding spares, personnel and other support resource utilization, deployment, stockpiling, changes in configuration, and/or maintenance concepts for optimization, etc. would be possible. This type of information would result in providing recommendations to the Services in ample time to permit the most economical and efficient planning and acquisition, as well as timely changes to occur.

**1.3 Implementation Considerations.** The target system will require that the major portions of the CALS attributes described in IDEF A1 and A2 are in place. With that prerequisite, the implementation of the appropriate managerial computerized techniques are minimal at best. Many standalone managerial techniques for accounting, scheduling and other managerial tasks are readily available on the commercial market. These are also

sufficiently flexible in design so as to easily handle the ILS tasks. They need only to be tied to the logistics data base, which by design will permit interfacing and two way communication of information/data and subsequent reports and feedback. Therefore, implementation should be relatively simple.

**1.4 Likely Payoffs and Benefits.** The target system provides the potential of properly managing the 'cradle to grave' contractor responsibility for reliability, supportability and support resource planning and preparation of an item of equipment, which is essential to the maximum utilization of the computerized techniques being planned for the actual performance of the tasks. Moreover it permits an interface and/or handover to the user of these controls and managerial techniques once he becomes organic.

**1.5 Changes Needed and Problems.** There are no specific changes needed. The processes of implementing the CALS will naturally lead to the computerizing of the managerial functions. There are no problems foreseen to accomplish the task.



## CALS FUNCTIONAL DESCRIPTIONS

### CONTRACTOR FUNCTIONS:

#### 3. IDEF A2, CALS Influence on Equipment Design



Table 2-5. IDEF A2, CONTRACTOR

## A2 Influence Design/Modification

This activity provides design guidance, analyses, and feedback during the design and development phases of equipment in order to achieve design attributes which will enhance the reliability, maintainability, and supportability of the equipment.

Reliability, Maintainability, and Logistics issues in design, particularly computer aided design (termed RAMCAD) provide the most essential portion of computer aided logistic support (CALS), in that they provide a design that is tailored and optimized not only from the standpoint of readiness and availability but also from supportability.

The products resulting from the computerized techniques also provide the information necessary for logistics support planning, for the preparation of technical manuals, the defining and optimization of spares procurement and placement, the technical requirements for test and other support equipment, as well as the test procedures, the built-in-test routines, and all the data necessary for the LSAR.

The process must take place during the active design phase prior to the release of drawings or design information for the manufacture of the equipment. In order to be as successful as possible, the task would require meaningful lessons learned feedback and comparison system information from the government. The maintenance concept, supportability specification, target support costs and the related portion of the performance requirements provided by the government would need considerable improvement from the manner in which these are specified today.

Design rules in terms of reliability, maintainability, safety and human factors information stored in libraries would have to be updated to reflect the present technology, and stores in a means that would be accessible by computer techniques. This would require changes on the part of the developer as well as the government. Computerized design and analytical techniques must be made to interact, or at least communicate, which presently presents considerable technical problems. The data collection and feedback system must be improved.

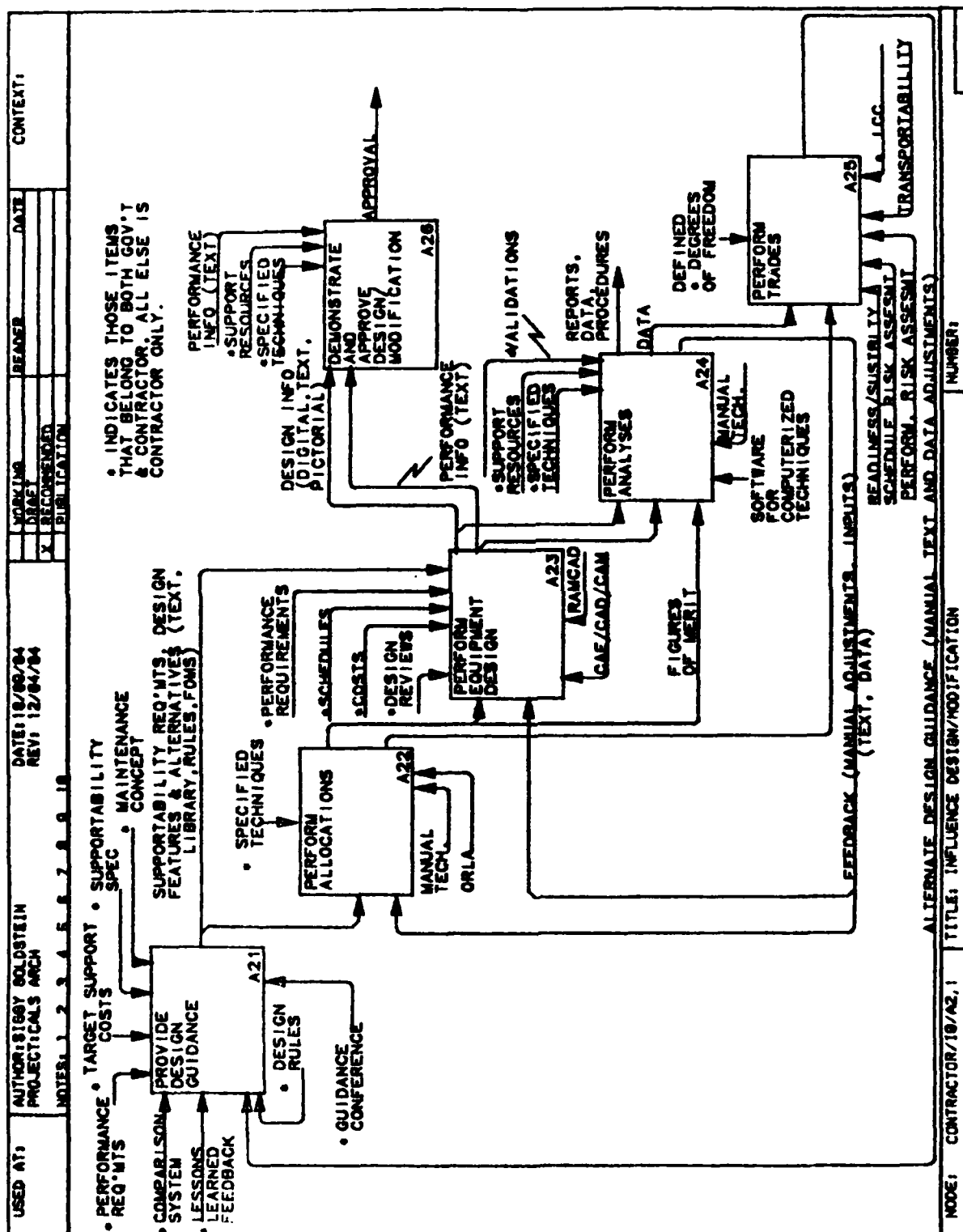


Figure 2-6. IDEF A2n, INFLUENCE DESIGN, CONTRACTOR

## A2 Influence Design/Modification (Con't)

Five activities describe the design/modification influence. The first of these is the provision for design guidance. This activity translates the Reliability, Maintainability and Supportability requirements of an equipment into terms that can be related to the designer in terms of guides, to his computer in terms of rules for rules checking, the quantitative portions of design rules and analytical goals in terms of figures of merit, as well as provide a library of information for use by the design and analyses programs.

The second activity is the performance of allocations. This task provides the equipment division or partitioning guidance to the design and allocates the Reliability, Maintainability quantitative requirements to the modules so partitioned. It also provides a library of parts for use by the design and performs tradeoffs between Reliability, Maintainability and Supportability issues.

Equipment design is the third activity. This is the process which results in the information necessary to build the equipment. The target system would provide for completely interactive design guidance, analyses and feedback, as well as for automatic optimization between trades of reliability, maintainability, supportability, mechanical/electrical packaging and modularization, performance, weight, volume and cost.

The fourth activity is the performance of analyses. The analytical techniques employ performance and design information as derived from drawings, performance specifications, timing diagrams, interconnection diagrams, etc. This activity prepares the Reliability, Maintainability, Testability, Human Factors, Safety, Transportability, and Optimum Repair Level Analyses of the design.

The last activity is the support of trades. The term trades connotes the sacrifice of one attribute for the enhancement of another. Unless all attributes remain within their specified limits, then the government must define the degrees of freedom that are allowed in these trades. It is assumed that these will be provided in the future and that they will include more than just the support cost alternatives that are presently allowed in that they will permit trade between size, weight, and performance. Presently trades are performed utilizing life cycle cost modelling and risk modelling.

### Glossary

Maintenance Concept - Equipment specification and/or maintenance scenario analyses at a higher level.

Supportability Specification - Specifications derived from supportability requirements.

Target Support Costs - Projected support costs supplied by certain contractual documents.

Performance Requirements - Those requirements implied by design specifications.

Table 2-6. IDEF A2, CONTRACTOR (sheet 2 of 3)

**A2 Glossary (Con't)**

**Comparison System** - The predecessor system upon which the present design is based. It will also contain lesson learned.

**Lessons Learned Feedback** - Field experience data reduced to cause and effect of problems.

**Design Rules** - Contractor support engineering design principles related to R, M & L.

**Guidance Conference** - Customer contractor interface meeting.

**Supportability Requirements** - Specified quantitative and qualitative requirements.

**Specified Techniques** - Analytical techniques performed in accordance with a contractually specified process.

**Manual** - Performed manually as opposed to computerized.

**RLA** - Repair level analysis. Determines the most cost effective repair level of an item.

**Schedules** - Time frames specified by the Contract Statement of Work.

**Costs** - Monetary restrictions specified by the Contract Statement of Work.

**Design Reviews** - Feedback of design analyses by the customer.

**Performance Information** - Specifications, tolerances, etc. as recorded during test procedures.

**Design Information** - Digital, pictorial, and text information used as input to Automated Authoring Systems for T.O.'s, test procedures, LSAR, spare buys decision documents, and contractor support engineering data.

**CAE/CAD/CAM** - Computer aided engineering, design, manufacturing techniques as owned by the contractor or provided as Government Furnished Equipment (GFE).

**RAMCAD** - Reliability, maintainability, and logistics issues in computer-aided design as owned by the contractor or provided as GFE.

**Figures of Merit** - Quantifiers of an attribute (ie MTBF for reliability).

**Validations** - Manual inputs from review of the analyses and/or demonstrations.

**Support Resources** - The items of support equipment tools, technical manuals, manpower, etc. necessary to support and maintain on equipment.

**Reports, Data, Procedures** - Input to Automated Authoring Systems for T.O.'s, test procedures, LSAR, spare buys decision documents, and contractor support engineering data.

**A2 Glossary (Con't)**

**Defined Degrees of Freedom** - Permissible excursions from norms, for use in trade-offs supplied by the Contractual Statement of Work and/or ILS Conference.

**LCC** - Computerized Life Cycle Cost analyses techniques as specified by the government with fixed constants provided by the government.

**Schedule Risk Assessment** - Contractor in-house developed techniques to assess risk in meeting schedules.

**Performance Risk Assessment** - Contractor in-house developed techniques to assess risk in complying with performance requirements.

**Readiness/Sustainability Assessment** - Computerized model as developed by the contractor or supplied GFE with which to project the degree of system readiness and operational sustainability.

**Transportability** - Computerized model as developed by the contractor or supplied GFE.

Table 2-7. (Sheet 1 of 3)  
DATA CONNECTIVITY INDEX FOR THE DESIGN IDEF CHART

<u>INFORMATION INPUT</u>	<u>FROM OR TO</u>
Comparison System	Data Collection and Feedback Systems
Lessons Learned Feedback	Data Collection and Feedback Systems
Design Rules	Software Library or Independent Pgm
<u>INFORMATION OUTPUTS</u>	
Performance Information	Automated Authoring Systems for T.O. (i.e., Specification and Tolerances) Test Procedures LSAR
Design Information	Automated Authoring Systems for T.O. Test Procedures LSAR Spares Buys Decision Documents Contractor Support Engineering Data
Analyses Reports, Data and Procedures	Automated Authoring Systems for T.O. Test Procedures LSAR Spares Buys Decision Documents Contractor Support Engineering Data
<u>CONTROLS</u>	
Maintenance Concept	Equipment Specification and/or Maintenance Scenario Analyses at a Higher Level
Supportability Specification	Equipment Specification and/or Maintenance Scenario Analyses at a Higher Level
Target Support Costs	Contractual Documents
Performance Requirements	Design Specifications



Table 2-7. (Sheet 2 of 3)  
DATA CONNECTIVITY INDEX FOR THE DESIGN IDEF CHART

<u>INFORMATION INPUT</u>	<u>FROM OR TO</u>
<u>CONTROLS</u> (Continued)	
Specified Analytical Techniques	Contract Statement of Work
Schedules	Contract Statement of Work
Costs	Contract Statement of Work
Design Reviews	Feedback of Design Analyses by the Customer
Validations	Manual inputs from Review of the Analyses and/or Demonstrations
Support Resources	Contractual Statement of work and/or ILS Conference
Defined Degrees of Freedom	Contractual Statement of Work and/or ILS Conference
<u>MECHANISMS</u>	
Guidance Conference	Customer Contractor Interface Meeting
RLA	Computerized Techniques as Specified by the Customer (the Computerized Model is usually either specified or given to the Contractor)
CAE/CAD/CAM	Computerized Techniques as owned by the Contractor or provided as Government Furnished Equipment
RAMCAD	Computerized Techniques as owned by the Contractor or provided as Government Furnished Equipment

Table 2-7. (Sheet 3 of 3)  
DATA CONNECTIVITY INDEX FOR THE DESIGN IDEF CHART

<u>INFORMATION INPUT</u>	<u>FROM OR TO</u>
<u>MECHANISMS</u> (Continued)	
LCC	Computerized Life Cycle Cost Analyses Techniques as specified by the Government with fixed constants provided by the Government. The technique is either provided by the Government or specified
Schedule Risk Assessment	Contractor in-house developed technique
Performance Risk Assessment	Contractor in-house developed technique
Readiness Sustainability	Computerized Model as developed by the Contractor or supplied GFE
Transportability	Computerized Model as developed by the Contractor or supplied GFE

IDEF A2, DESCRIPTION  
CALS INFLUENCE ON EQUIPMENT DESIGN

1. DESIGN INFLUENCE

a. Current Status: Presently the analytical techniques employed are performed in series with a design, where feedback becomes costly in terms of design changes and schedule slippages.

b. Target System Characteristics: This task provides design guidance, analyses, and feedback during the design and development phases of an equipment in order to achieve design attributes which will enhance the reliability, maintainability, and supportability of the equipment.

c. Benefits: Reliability, Maintainability, and Logistics issues in design, particularly computer-aided design (termed RAMCAD), provide the most essential portion of computer-aided logistic support (CALS), in that they provide a design that is tailored and optimized not only from the standpoint of readiness and availability but also from supportability. The products resulting from the computerized techniques also provide the information necessary for logistics support planning, for the preparation of technical manuals, the defining and optimization of spares procurement and placement, the technical requirements for test and other support equipment, as well as the test procedures, the built-in-test routines, and all the data necessary for the LSAR.

In addition, if feedback were provided while a design is being prepared, design enhancements which may improve RM&S well beyond what is specified will not affect cost, schedule or performance of the equipment. To the contrary, it may even improve these because the analytical techniques employed would discover design problems, input/output mismatches, manufacturing and test problems, etc. The techniques would also provide the

most authoritative and useful products for the logistic support planning and resources.

d. Problems: The process must take place during the active design phase prior to the release of drawings or design information for the manufacture of the equipment. In order to be as successful as possible, the task would require meaningful lessons learned and feedback and comparison system information from the government. The maintenance concept, supportability specification, target support costs and the related portion of the performance requirements provided by the government would need considerable improvement from the manner in which these are specified today. Design rules in terms of reliability, maintainability, safety and human factors information stored in libraries would have to be updated to reflect the present technology, and stored in a means that would be accessible by computer techniques. This would require changes on the part of the developer as well as the government. Computerized design and analytical techniques must be made to interact, or at least communicate, which presently presents considerable technical problems. The data collection and feedback system must be improved.

e. Implementation Approach: There is no single input or single analytical technique that can achieve the desired results. The various inputs and analyses (typical analyses are provided in Table 2-10) are interdependent, as shown in the lower IDEF level charts. This requires the development of either interactive techniques or a rapid, error free means of transferring data from one program to the other so as to provide a reasonable cycle of analyses and feedback. To be effective, this cycle should take no longer than it takes to test the performance adequacy of the evolving design; anywhere from a few minutes to two days.

The rapid development of independent analytical computerized techniques for design assistance and analyses would indicate that

a two step process for implementation is the most feasible at this time. The first step would be to develop the means to communicate between the various programs; and the second step would be to make them interactive.

f. Implementation Cost: Very high.

#### 1.1 DESIGN GUIDANCE

a. Current Status: Presently much of this is done manually by the Reliability, Maintainability and Supportability engineers as part of the LSA process. Requirements are given the designer by indoctrinations or written design guides. However, inputs are generally limited to what is contained in the specification and the illities engineers' own experience.

b. Target System Characteristics: This task translates the Reliability, Maintainability and Supportability requirements of an equipment into terms that can be related to the designer in terms of guides; to his computer in terms of rules for rules checking; the quantitative portions of design rules and analytical goals in terms of figures of merit; as well as providing a library of information for use by the design and analyses programs.

c. Benefits: This is the first step in tailoring a design to make it fit the support and maintenance concept required by the user.

d. Problems: To be effective, the Reliability, Maintainability and Supportability portions of a design specification must contain requirements which were properly tailored and allocated to the equipment from the overall maintenance and support concept by the government. Quantitative requirements concerning built-in-test, testability, etc. would be ranked in the order of importance, and tied to specific performance attributes. Field data collection systems would

be more effective, and the information contained in a computerized library, which could be remotely accessed with search and sort modes available. As shown, a guidance conference at the very beginning of a program is an essential mechanism to the success of design guidance.

e. Implementation Approach: The translation of the requirements to the necessary outputs requires expert subjective opinion and therefore must remain a manual task performed by experienced illities engineers. The computerized output products, however, must be provided in such fashion that they are accessible to the computer-aided design program as well as the computerized analytical techniques which will be employed. This would require the same development strategy of communications technique previously mentioned.

f. Implementation Cost: Very high.

## 1.2 ALLOCATIONS

a. Current Status: Presently this task is performed manually using computerized stand-alone programs such as the Repair Level Analyses and Life Cycle Cost Models.

b. Target System Characteristics: This task provides the equipment division or partitioning guidance to the design and allocates the Reliability, Maintainability quantitative requirements to the modules so partitioned. It also provides a library of parts for use by the design and performs tradeoffs between Reliability, Maintainability and Supportability issues.

c. Benefits: This task provides the design-to-goals or Figures of Merit (FOMs) to be contained in the LSAR.

d. Problems: None.

e. Implementation Approach: The task requires expert judgment. It should therefore remain primarily a manual task, utilizing computer techniques only as tools to generate the information needed to make the judgment.

f. Implementation Cost: None.

### 1.3 EQUIPMENT DESIGN

a. Current Status: Presently the design process is evolving into one which employs computer techniques to assist the designer in attaining the performance (CAE), in rendering the drawings (CAD), and, if automated, machine tool information (CAM). It is assumed that this process will continue to be enhanced to the point where it will be universally utilized in such manner that the design programs could directly interact or provide/accept information from analytical programs which are involved with the performance of the item being designed. This would be the collection of programs termed RAMCAD. Presently the analytical techniques are performed without such interaction even though they may use stand-alone computerized techniques that are available today to perform most of the analyses required by Reliability, Maintainability, and Supportability (See Table 2-8).

b. Target System Characteristics: This is the process which results in the information necessary to build the equipment. The target system would provide for completely interactive design guidance, analyses and feedback, as well as for automatic optimization between trades of reliability, maintainability, supportability, mechanical/electrical packaging and modularization, performance, weight, volume and cost.

c. Benefits: This task provides for the influencing of a design such that its reliability, maintainability, supportability

Table 2-8. (Sheet 1 of 5)

## LIST OF R, M, AND L DESIGN-RELATED ANALYTICAL TECHNIQUES

	<u>NAME</u>	<u>REFERENCE</u>
1	RELIABILITY ANALYSES:	MIL-STD-1388-1A, Tasks 301
1.1	Parts failure rate catalogue for allocations and worst case analyses	MIL-HDBK-217
1.1.1	Lessons learned failure rate feedback to modify 1.1	MIL-STD-1388-1A 501.2
1.1.2	Mission thermal, mechanical stress profile for application in catalogue search	MIL-STD-1388-1A 301.2.4
1.2	Reliability Predictions	MIL-STD-785 Task 203 MIL-STD-756 MIL-HDBK-217
1.2.1	Basic prediction from parts application, packaging and function configuration of the design	MIL-STD-785 Task 203 For use in FMECA and MIL-STD-1388-2A Data Record B
1.2.1.1	Circuit analyses to determine electrical stresses under operating conditions to: (1) modulate 1.2.1, and (2) identify overstresses	
1.2.1.2	Circuit Analysis to determine thermal stresses under operating conditions to: (1) modulate 1.2.1, and (2) identify overstresses	
1.2.1.3	Construction analysis to determine physical stresses under operating conditions to: (1) modulate 1.2.1, and (2) identify overstresses	



Table 2-8. (Sheet 2 of 5)

## LIST OF R, M, AND L DESIGN RELATED ANALYTICAL TECHNIQUES

NAME	REFERENCE
1.2.2 Mission reliability prediction based on functional block diagram, mission profiles, operational scenarios, redundancies, work-a-rounds, degradations, etc.	MIL-STD-785 Task 203 For use in FMECA and MIL-STD-1388-2A Data Record B
1.2.3 Construction of reliability block diagram for use in other analyses such as FMECA, BIT and Test Point, LSA R, etc.	MIL-STD-785 Task 203 For use in FMECA and MIL-STD-1388-2A Data Record B
1.3 Failure Modes, Effects and Criticality Analysis	MIL-STD-785 Task 204 MIL-STD-1388-1A, Task 301.2.4.1
1.3.1 Functional Block Diagram of the item under analysis for use in the FMECA, maintainability analysis, LSA R and technical manuals	MIL-STD-1629, Task 101, 4.1.4
1.3.2 Failure Modes and Effects Analysis Hardware approach	MIL-STD-1629, Task 101
1.3.2.1 Top down technique	
1.3.2.2 Bottom up technique	
1.3.3 Failure Modes and Effects Analysis Functional approach	
1.3.3.1 Top down technique (preferred for later use in BIT, Test Point, Maintainability and Maintenance Task analyses, as well as in developing fault isolation strategies)	
1.3.3.2 Bottom up technique	
1.3.4 Some combination of 1.3.2 and 1.3.3	
1.3.5 Criticality Analysis	MIL-STD-1629, Task 102

Table 2-8. (Sheet 3 of 5)

## LIST OF R, M, AND L DESIGN RELATED ANALYTICAL TECHNIQUES

NAME	REFERENCE
1.3.5.1 Qualitative approach	
1.3.5.2 Quantitative approach	
1.3.5.3 Construction of Criticality Matrix	
1.3.6 FMECA Maintainability Information This would require the combining of other analytical results such as from BIT and Test Point analyses	MIL-STD-1629, Task 103
1.4 Sneak Circuit Analyses Also for input to, or use in, BIT and Test Point Analyses, Testability analysis, construction of test procedures, etc.	MIL-STD-785, Task 205
1.5 Electronic Parts/Circuit Tolerance Analysis For use in design evaluation, risk analysis and reliability prediction	MIL-STD-785, Task 206
1.6 Reliability Centered Maintenance	MIL-STD-1388-1A, Task 301.2.4.2, MIL-STD-785, Task 209
1.7 Parts Control	MIL-STD-785, Task 207 MIL-STD-138-1A, Task 301
1.7.1 Design guides including junction temperatures allowed, derating requirements, parts application, margins of safety, etc.	
1.7.2 Identification of Reliability Critical Items	MIL-STD-785, Task 208
1.8 Reliability Risk Analysis	MIL-STD-1388-1A, Task 301.2.3

**Table 2-8. (Sheet 4 of 5)**  
**LIST OF R, M, AND L DESIGN RELATED ANALYTICAL TECHNIQUES**

	NAME	REFERENCE
2	MAINTAINABILITY ANALYSES:	MIL-STD-1388-1A, Tasks 300
2.1	Elemental maintenance actions catalogue including maintenance times and skills	MIL-STD-1388-1A, Task 300.2.4 MIL-HDBK-472
2.2.1	Lessons learned feedback for task times and difficulties	MIL-STD-1388-1A, Task 501.2
2.2.2	Maintenance/use profile input to adjust elemental task times and skills	MIL-STD-1388-1A, Task 301.2.4
2.2	Maintenance access analysis	MIL-STD-280
2.3	Operating and Maintenance Task Analysis For inputs to the Maintainability prediction, technical manuals and LSA R	MIL-STD-1388-1A, Task 301.2.4.3
2.4	Maintainability Prediction	MIL-STD-470 MIL-HDBK-472
2.4.1	MIL-HDBK-472, Procedure 1	
2.4.2	MIL-HDBK-472, Procedure 2 There are many adaptations of this procedure. Its the most rigorous	
2.4.3	MIL-HDBK-472, Procedure 4	
2.4.4	A RINC Fault Symptom Model	RADC-TR-70-89
2.5	Built-in-Test Analysis For use in design analysis, integrated diagnostics trades, Operational Availability predictions LSA R, etc.	MIL-STD-1388-1A, Task 301.2.4

**Table 2-8. (Sheet 5 of 5)**  
**List of R, M, and L Design Related Analytical Techniques**

NAME	REFERENCE
2.6     Testability Analysis Used for design analysis, test point placement	MIL-STD-1388-1A, Task 301.2.4
2.6.1     UUT Compatibility with automatic test equipment. For use in design analysis, integrated diagnostics trades, preparation of test requirements, LSAR, etc.	MIL-STD-2076
2.6.2     Test time analysis	MIL-HDBK-472
3     ITEMS FOR INTEGRATED LOGISTICS TASKS	
3.1     Level of Repair Analyses	MIL-STD-1388-1A, Tasks 303
3.2     Life Cycle Cost Analyses	MIL-STD-1388-1A, Tasks 303
3.3     Integrated Diagnostics Tradeoff	MIL-STD-1388-1A, Tasks 303
3.4     Design Interface Compatibility Check	
3.4.1     Check on connector pin assignments vs signal names, signal types and signal tolerances. For checking designs (for interfacing), inputs to support equipment, test and calibrations requirements, and inputs to Technical Manuals	
3.4.2     Check on signal names from signal origin to destination through the signal flow diagrams as well as the schematics. For design analysis and Technical Manuals source Material accuracy check	

and readiness related design attributes are optimally included in the design features. This task also provides the generation and communication of performance information required for preparation of technical manuals as well as the electrical/mechanical design information for that same purpose. It could provide, if properly structured, the parts lists required for spares planning data, as well as the illustrated parts breakdown, and also provide the pictorial information necessary for technical manuals and illustrated parts breakdowns. It could also provide a transcription of the specified performance requirements in such manner that it can be used for the LSAR, as well as the descriptive portion of a technical manual.

d. Problems: The programs employed for designing an equipment generally interact with the programs for preparing a drawing or preparing the digital information from which to manufacture an item. This results in the ultimate information being in a format that is not readily usable by text processors, or analytical techniques which require quantities such as dimensions, voltages, waveforms, timing diagrams, etc., from the field of a drawing.

e. Implementation Approach: A three step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is rapidly available, with no manual transcription required. The second step could also provide for developing Government furnished programs that may be made available to suppliers who can not afford to develop or purchase their own. The third step would be to develop the technique, or interfacing Executive, to make the various programs interactive.

f. Implementation Cost: Very high.

## 1.4 ANALYSES

a. Current Status: Presently the analytical techniques employ performance and design information as derived from drawings, performance specifications, timing diagrams, interconnection diagrams, etc. Techniques employed are those listed in Table 2-8, many of which are already available in computerized techniques from software houses, as well as in-house-developed programs. Manual techniques are also used, especially in cases where subjective analyses as well as mock-ups are utilized, such as in human factors and safety analyses.

b. Current Status: This task prepares the Reliability, Maintainability, Testability, Human Factors, Safety, Transportability, and Optimum Repair Level Analyses of the design.

c. Benefits: The final output of the analyses provides the instrument for design approval. Depending on contractual requirements this can vary from the comparison of the results of the analysis with the allocations, or to performing a demonstration of the attribute being analyzed, such as the MTBF for Reliability.

The output of the analyses also provides all of the data that are necessary for the LSAR. They could also provide the test program sets for use of automatic test equipment, the built-in-test routines with which to program the built-in-test computer, training material, detailed step-by-step procedures for assembly/disassembly, and similar repair actions. Detailed timing diagrams and test point signatures can also be provided. The Repair Level Analyses are also the trades necessary to optimize the repair facilities, spares buys and placement, and transportation issues.

d. Problems: Inputs to the analyses require translation of information from the fields of drawings or contents of digitized design information in such a manner that they are useful for calculations and text processing. Programs to perform this type of translation are not available yet, though the problem is being addressed in standardization specifications such as IGES. Presently this transition is performed manually and is subject to high cost, long lead times, long reaction times, and considerable error.

e. Implementation Approach: A three step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is rapidly available, with no manual transcription required. The second step would be to develop analytical techniques that are required, but not considered to become available in the near future. The second step could also provide for developing government furnished programs that may be made available to suppliers who can not afford to develop, or purchase their own. The third step would be to develop the technique, or interfacing Executive, to make the various programs interactive.

f. Implementation Cost: Very high.

## 1.5 TRADES

a. Current Status: The term trades connotates the sacrifice of one attribute for the enhancement of another. Unless all attributes remain within their specified limits, the government must define the degrees of freedom that are allowed in these trades. It is assumed that these will be provided in the future and that they will include more than just the support cost alternatives that are presently allowed, in that they will permit trade between size, weight, and performance. Presently trades are performed utilizing life cycle cost modeling and risk modeling.

b. Target System Characteristics: This task provides for optimizing Reliability, Maintainability, Supportability, and other design attributes. Future trades would also use these models with final decisions being made by expert judgment. Future trades, however, would also model readiness and sustainability, as well as the effects on transportability. The latter should be modeled in such a way as to interact with the modularization of the equipment being designed, which in turn would interact with provisioning costs, stocking levels, and warehousing considerations.

c. Benefits: The process of trades is one of optimization between equipment design features for Reliability, Maintainability and Supportability versus the capability and cost of the support resources. As such it is the key to the process that determines the cost and features in the equipment being supported, versus the cost of features of the resources necessary to support that equipment.

d. Problems: To be effective, trades require accurate user inputs as concerns the application of equipment, its maintenance scenario, the desired/available support equipment, skills, and training limitations, as well as the government supplied input quantifiers for the life cycle cost modeling. These all have to accurately fit the situation being modeled and must include the proper overhead costs, otherwise the results of the model would always be skewed towards government labor intensive support, and be highly inaccurate. The reason for this inaccuracy is that all other (non-labor) comparisons are made on the basis of actual cost to the government.

e. Implementation Approach: Trades require the interaction of the results of the many analytical models discussed. The recommended approach therefore is to complete the communications capability of these models, and in parallel develop an expansion of a universally applicable life cycle cost model that can trade the various issues in terms of relatable



or equivalent cost factors. When that is completed, the automatic interaction of these models should be developed. It should also be considered that both stages of development can be accomplished in several steps, adding the simpler trades, namely those that are readily equatable to cost, first, and then applying expertise judgment/ranking to the remainder, while evolving the entire technique. In this manner, individual layers of sophistication could be demonstrated separately and their accuracy and utility validated and evaluated more readily.

f. Implementation Costs: High

#### 1.6 DEMONSTRATE AND APPROVE

a. Current Status: The demonstration, or validation of compliance with specified Reliability, Maintainability, and supportability requirements is usually performed on actual equipment using manual techniques. Occasionally it may consist of evaluating the analytical results which were used to prove compliance, but that too is a manual task.

The subtasks associated with the task requires the development of test procedures, the actual validation/demonstration and the assimilation of test results. The preparation of test procedures is the only task with a relatively high potential for application of computerized techniques.

b. Target System Characteristics: As the testability analyses programs become more sophisticated, the development of checkout and fault isolation procedures will follow as a natural output of these analyses. This could provide for automated preparation of test programs for automatic test equipment, the BIT, as well as for preparation of step-by-step procedures to be used in technical manuals. A number of limited (in analytical

complexity) programs are already available. These programs would then also be required to be used in equipment validation/demonstration. Test results could also be compared to the results expected as derived from the testability analyses. This would be computerized, but since it is a relatively simple yet objective task, it would remain to be best performed manually. Computerized techniques could compare the configuration and source of the information of the various analyses to be combined so as to make that traceability/cataloging easier for the final analyst.

c. **Benefits:** The test procedures, fault isolation procedures and procedures for repair sections employed in the validation/demonstration are normally specified to be included in the technical manuals, or at least form a significant technical input to them. Normally, however, the scheduling is such that this does not happen. The use of computerized techniques for the preparation of that material will make it available at the time of design release completely eliminating this problem, and enabling the proper preparation of training material, technical manuals, checkout and fault isolation procedures, and support equipment recommendations. Computerized assimilation of validation/demonstration results (as well as assembly line testing) will provide instant feedback, enabling timely correction of any procedural errors.

e. **Implementation Approach:** A three step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is rapidly available, with no manual transcription required. The second step would be to develop analytical techniques that are required, but not considered to become available in the near future. The second step could also provide for developing Government furnished programs that may be made available to suppliers who can not afford to develop or purchase their own. The third step would

be to develop the technique or interfacing Executive to make the various programs interactive.

f. Implementation Cost: Low.

#### 1.6.1 START DIAGNOSTIC PROCEDURES

a. Current Status: This task has usually been performed manually, since it is based on the design requirements rather than firm design information.

b. Target System Characteristics: This is a rough cut procedure for fault detection and fault isolation. Prior to performing any other trades, modern electronic design is structured to result in functional packaging in order to facilitate fault detection and fault isolation, as well as to minimize the number of signals that have to enter and leave a module, since this interrelation between modules would then naturally occur at functional nodes. (Functional packaging limits commonality.)

In the future, manual techniques are also envisioned to be best suited for this judgmental process, because it requires knowledge of overall performance, signal flows, and feasible divisions into nodes. The outputs are also best left in written format, since most of the allocation process will be subjective and employ manual techniques.

c. Benefits: This process results in the equipment partitioning and the allocation of FOMs which will ultimately be entered into the LSAR. The partitioning will determine the modularization, standardization, testing, repair, transportation, etc. attributes of the equipment and its modules.

d. Problems: None.

e. Implementation Approach: None.

f. Implementation Cost: None.

#### 1.6.2 EQUIPMENT PARTITIONING

a. Current Status: The information regarding the test nodes and ambiguities resulting from the diagnostic procedure are normally provided in hard copy for review by a senior level engineer. The task usually involves tradeoffs which are technical in nature as concerns the division by nodes, mechanical in nature as concerns the amount of circuitry that can be placed within the module being designed, the cause/effect information available from the RLA, and the trades of task 1.6.4. This task is performed manually, with computerized techniques assisting in the mathematics of the tradeoffs, such as the RLA.

b. Target System Characteristics: This task provides the division of an equipment or an assembly into its next lower level of assembly. It utilizes the test node information from the diagnostic procedure, as well as the RLA to perform this task. The model(s) would automatically optimize between division for the sake of testability (functional), packaging and transportability, cost (standardization and multi-application), performance, etc. as part of the design process.

c. Benefits: This process results in the equipment partitioning and the allocation of FOMs, which will ultimately be entered into the LSAR. The partitioning will optimize the modularization, standardization, testing, repair, transportation, etc. attributes of the equipment and its modules between performance and supportability considerations.

d. Problems: This process requires the development of the proper cost factors as for Trades, paragraph 1.5.

e. Implementation Approach: Same as 1.5.

f. Implementation Cost: Same as 1.5.

### 1.6.3 RELIABILITY ALLOCATION

a. Current Status: The technique utilizes a parts library for MIL-HDBK-217 based predictions, as well as inputs from GUIDEP's data base. Presently the task involves a mix of manual and computerized techniques, with the latter normally associated with just the parts assignment and search of the GUIDEP files.

b. Target System Characteristics: This task provides the allocated MTBF to the module as it has been partitioned, as well as narrowing the selection of preferred parts to be used in the design of the module. The search of the parts library as it is done today could possibly be improved in that the process of designing a performance of an item could very well narrow down the range of parts that could provide that performance, and with that precondition could save a considerable amount of time. Also, if done properly, the precondition and subsequent parts selection could result in the parts listing to be contained on the drawing's bill of material automatically, as well as be provided in text processor format for use in editing into parts lists and LSAR inputs.

c. Benefits: This task results in the selection of components for use in the equipment design, LSAR H sheets, as well as the allocated MTBF for use in the LSAR A sheet.

d. Problems: There are no problems anticipated with the library function, since many programs already exist that can do this. The design interactive portion, however, needs the same development as the analytical techniques previously discussed.

e. Implementation Approach: A two step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is available rapidly, with no manual transcription required. The second step would be to develop the technique, or interfacing Executive, to make the various programs interactive.

f. Implementation Cost: Low.

#### 1.6.4 TRADES

a. Current Status: Presently trades are performed using life cycle cost modeling and risk modeling. Future trades would also use these models, but with the final decisions being made by expert judgment.

b. Target System Characteristics: This task provides for optimizing Reliability, Maintainability, Supportability, Design and Maintenance Concepts during the allocation process. Future trades, however, would also model readiness and sustainability, as well as the effects on transportability. The latter would be modeled in such a way as to interact with the equipment partitioning or modularization of the equipment being designed, which in turn would interact with the maintainability allocations and reliability allocations.

c. Benefits: The process of trades is one of optimization between equipment design features for Reliability, Maintainability and Supportability versus the capability and cost of the support resources. As such, it is the key to the process that determines the cost of features in the equipment being supported, versus the cost of features of the resources necessary to support that equipment. See also 1.5.

d. Problems: To be effective, trades require accurate user inputs as concerns the application of equipment, its maintenance scenario, the desired/available support equipment, skills and training limitations, as well as the government supplied input quantifiers for the life cycle cost modeling. These all have to accurately fit the situation being modeled and must include the proper overhead costs, otherwise the results of the model would always be skewed towards government labor intensive support and be highly inaccurate. The reason for this inaccuracy is that all other (non-labor) comparisons are made on the basis of actual cost to the government.

e. Implementation Approach: See 1.5.

f. Implementation Cost: High.

#### 1.6.5 MAINTAINABILITY ALLOCATIONS

a. Current Status: The technique utilizes the allocated MTBF to allocate repair times in inverse proportion to failure rates, wherever possible. Task time estimates are input from guides such as MIL-HDBK-472. Presently the task is performed manually. The mathematics are relatively simple and judgment is required in those cases where adjustments have to be made to the allocation to truncate resulting low repair times for realism, and high repair times so as not to exceed specified maximum repair times. Computerized techniques would speed the process somewhat, but is not essential for this task.

b. Target System Characteristics: This task provides the allocated MTTR to the module as it has been partitioned. It also serves to separate task times between testing tasks, remove and replace tasks, and repair tasks. As such the task results in the first identification of skills, manpower requirements, and repair times for use in the LSAR and training plans.

d. Problems: The task requires interpretation of the supportability requirements as well as a determination of how to handle the ambiguities that have been identified in the early diagnostic procedures. This requires expert judgment and therefore a hard copy information transfer for the analyses of this information. This would indicate that at best computer techniques could be used in assisting the analyst only in the mathematical portions of this process, until such time as the interactive portions of the partitioning program are developed.

e. Implementation Approach: It is recommended that the present procedure continue as is until the partitioning programs(s) has been developed. The maintainability allocations would then be one of its outputs.

f. Implementation Cost: There is no cost peculiar to this implementation.

#### 1.6.6 FIRST CUT FMECA

a. Current Status: The technique uses conceptual design information and the translated supportability requirements. As such is requires expert judgment and is performed manually.

b. Target System Characteristics: This task tests the equipment partitioning from a standpoint of assessing the effect and propagation of functional failures. It identifies problems in performance degradation, fault detection, fault isolation, as well as critical failures and parts. Its function in the allocation process is primarily one of optimizing the equipment partitioning, identifying potential design problems, and attempting to prevent the use of critical components and circuits. There are digital techniques available, but these are usually used when design information is available during the analytical process.



c. Benefits: This task is part of the optimization process during the allocation of Reliability and Maintainability quantifiers, as well as the equipment partitioning. It is therefore a key element in the development of design features to enhance Reliability, Maintainability and Supportability.

d. Problems: None.

e. Implementation Approach: None.

f. Implementation Cost: None.

#### 1.6.7 RELIABILITY STRESS ANALYSES

a. Current Status: Presently the analyses are performed with stand-alone modules of computerized techniques, which are available either off-the-shelf or as in-house developed. Except perhaps for small companies, very few of these analyses are performed manually today.

b. Target System Characteristics: This task analyzes a proposed design to determine the effect of stress on the performance and reliability of that design. The analysis requires detailed design information. Electrical design and component information is required to perform electrical stress analyses. The electrical stress analyses apply to parts location information. Ambient/cooling air information is required for thermal stress analyses. An environmental profile, together with mechanical layout and packaging information, is required to perform environmental stress analyses, which could range from temperature and mechanical shock to vibration and other mechanical stresses on the components, as well as the chassis or circuit board upon which these are mounted. The assumption is that all this information will be available to the analytical techniques of the future, such that these analyses could be performed interactively with a CAE/CAD program.

c. Benefits: Properly applied, the results of these analyses can become a major contributor towards improving reliability of a design. The results also provide the updated Reliability predictions which are utilized in the Maintainability Analyses and the LSAR.

d. Problems: Inputs to the analyses are derived directly from schematics and mechanical drawings. However, the information that is required by these techniques is the technical content of these drawings rather than the pictorial representation. This could very well provide a problem in communicating from a CAD prepared drawing, in which the information is digitized in the form of a pictorial rather than an information content. Interacting directly with the program that prepares schematics or mechanical layouts may present another problem in that off-the-shelf software that prepares drawings may not have the provision to interact with an analytical program. Environmental requirements are normally FOMs as provided from the performance information, and therefore could be applied directly as inputs to the analyses. Equally, the allocations should present no problems for inputting. The output of the stress analyses, as concerns component placement, should also interact with the mechanical drawing software, otherwise that software would have to be entered again manually to change the original layout. This could be time-consuming and prone to error.

e. Implementation Approach: A three step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is available rapidly, with no manual transcription required. The second step would be to develop analytical techniques that are required, but not considered to become available in the near future. The second step could also provide for developing Government furnished programs that may be made available to suppliers who can not

afford to develop, or purchase their own. The third step would be to develop the technique or interfacing Executive to make the various programs interactive.

f. Implementation Cost: Low.

#### 1.6.8 TESTABILITY ANALYSES

a. Current Status: Presently the analyses are performed by both manual and automated techniques. Manual techniques are used where a sufficient library of components is not available to perform these techniques automatically, or where the specifications are sufficiently liberal so that a simple checklist such as may be found in MIL-STD-2076 would suffice. Very powerful analytical techniques exist today. These require inputs in the form of the schematic and, as a minimum, the range of input test stimuli. The programs that analyze performance also require the desired/specified transfer characteristics of the circuit in order to assess its capability to perform that function.

b. Target System Characteristics: This task analyzes a circuit to determine whether or not it is testable for all its performance attributes with the test facilities that are resident in the circuit. There are two major approaches to this. One is a by-product of a circuit analyses for purposes of determining its capability to perform its intended function, which is sometimes labeled a sneak circuit analyses or circuit performance analyses. The other is a purely statistical technique. The statistical technique will only provide a figure of merit, whereas the detailed analyses will actually provide information for test point placement as well as the development of fault isolation procedures.

c. Benefits: This task provides for the testability aspects of the equipment being designed. It also provides the

information necessary to develop the test procedures, fault isolation procedures, and built-in-test routines. When properly structured, these could be developed into technical manual information, as well as the actual test procedures to be used by the support equipment.

d. Problems: The input requirements are very much the same as for the Reliability Stress Analyses in that technical information content of a schematic is required. Depending on the circuit complexity and component fan-outs, a program can take several hours to run. To be effective, time must be scheduled for that assessment such that feedback and corrective action in a design process can take place.

e. Implementation Approach: A three step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is available rapidly, with no manual transcription required. The second step would be to develop analytical techniques that are required but not considered to become available in the near future. The second step could also provide for developing Government furnished programs that may be made available to suppliers who can not afford to develop or purchase their own. The third step would be to develop the technique, or interfacing Executive, to make the various programs interactive.

f. Implementation Cost: Low.

#### 1.6.9 FMECA

a. Current Status: Presently there is software available either off-the-shelf or contractor-developed to perform these analyses on relatively complex equipment. The software, however, requires manual inputs to it. The information that the program

utilizes should be readily available from the Reliability Stress Analyses and Testability Analyses in a format suitable for direct input.

b. Target System Characteristics: This task provides the failure modes, effects and criticality analyses of the item being designed, as well as its next higher level of assembly from inputs provided to it automatically from the design process, and the results of the reliability and testability analyses.

c. Benefits: The task sets priorities in utilization of test facilities, which will determine the arrangement of test procedures, built-in-test routines, Maintainability and Maintenance Tasks Analyses.

d. Problems: None.

e. Implementation Approach: Since many models already exist, only the communications and interaction with other programs need to be developed. However, this development is part of the modernizing of the analyses programs and therefore needs no special, peculiar attention.

f. Implementation Cost: None.

#### 1.6.10 TRANSPORTABILITY AND REPAIR LEVEL ANALYSES

a. Current Status: The analytical techniques are well specified in military standards and handbooks, and are simple enough to be performed manually, as is presently done. The RLA modeling has used computerized techniques for many years. There are a considerable amount of models available to do this. All of the models, however, require manual input to them. The outputs are printouts and summaries. The inputs are primarily numeric in nature and could readily be available from digitized outputs of Maintainability, Reliability, and appropriate design information.

b. Target System Characteristics: Transportability issues have rarely played a major role in the partitioning of an equipment. This is due to the fact that in most situations the transportability cost factors are an extremely low part of life cycle costs. However, they could be significant for delicate equipment or equipment that requires frequent overhaul at remote locations. It is envisioned that an output of this analyses could be digitized in such manner as to be interactive with the RLA and the partitioning analyses. The RLA in turn seeks to ascertain the most economical maintenance and maintenance level of the item in question. It uses life cycle cost modeling with which to test the cost effectiveness of each maintenance concept evaluated, including that of discard. The target system would provide for automatic inputting to the model, as well as its interaction with the other models described under Trades, paragraph 1.5.

c. Benefits: This task analyzes the handling and transportation requirements of an item of equipment. It is usually limited to the assembly and sub-system level. Transportation factors are a direct input to the LSAR. The RLA is an essential determinant for system division, standardization among modules and the planning for support resources. The results of the RLA are also a direct input to the LSAR and the maintenance codings of the spares lists.

d. Problems: The same problems of developing the interactive techniques as for other analyses apply here. This interaction with other analytical techniques needs to be developed. This interaction, however, will be part of the development of the other techniques and will not require any peculiar attention for this task.

e. Implementation Approach: A three step approach for the transportability analysis is recommended. The first would be

to provide for communication between the presently available design assistance and analyses programs such that information is rapidly available with no manual transcription required. The second step would be to develop analytical techniques that are required, but not considered to become available in the near future. The second step could also provide for developing Government furnished programs that may be made available to suppliers who can not afford to develop or purchase their own. The third step would be to develop the technique, or interfacing Executive, to make the various programs interactive. No special implementation is required for the RLA because it will be a fallout of developing other analytical technique interfaces.

f. Implementation Cost: Low.

#### 1.6.11 MAINTAINABILITY ANALYSES

a. Current Status: Presently this task is performed primarily utilizing manual techniques, with assistance by computers or calculators to do the mathematics.

b. Target System Characteristics: This task prepares the Maintainability Analyses of a design. The final, detailed Maintainability Analyses require input from the Reliability Analyses, the Testability Analyses, the Test Procedures, the FMECA and design information in terms of the assembly, cabling, assembly process, components and component placements, fasteners, nomenclatures, and reference designators. Feedback from the Repair Level Analysis, if performed, is also required. Since the mathematics are relatively simple, it is assumed that computerized techniques interactive with an analyst should be possible in the very near future to facilitate this task.

c. Benefits: The output of this task results in the MTTR prediction, as well as the elemental task times and skills that

are necessary to perform equipment repair. These are direct inputs to the LSAR or, if so provided, the validation requirements of the contract.

d. Problems: Inputs to the analyses require translation of information from the fields of drawings or contents of digitized design information in such manner that they are useful for calculation of the elemental tasks involved in maintenance. This technology is not yet available, although standardization specifications such as IGES address the requirements. The elemental tasks on the other hand present no problem since they are usually derived from a handbook and could very well be contained in a computerized library.

e. Implementation Approach: A three step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is rapidly available, with no manual transcription required. The second step would be to develop analytical techniques that are required but not considered to become available in the near future. The second step could also provide for developing government furnished programs that may be made available to suppliers who can not afford to develop or purchase their own. The third step would be to develop the technique, or interfacing Executive, to make the various programs interactive.

f. Implementation Cost: None.

#### 1.6.12 HUMAN FACTORS AND SAFETY ANALYSES

a. Current Status: This task is normally performed manually prior to a drawing release, or shortly thereafter. This task is based on the rules available from military specification and handbooks and could therefore become a CAE/CAD available rule



library; at least for the straightforward "good design practices" design checking. It is assumed that eventually this will automatically become part of electrical and mechanical CAE. If so, this would leave the anthropometric analyses, which are presently in development.

b. Target System Characteristics: This analyses will automatically analyze the design from the standpoint of work access and other anthropometric considerations. It will, together with the Maintainability Analyses, determine the task and skill requirements, as well as training requirements of the maintainer and operator. Since the Safety Analyses are closely linked to the Human Factors Analyses and ascertain dangerous voltages, power levels, hazardous tasks, sharp edges, toxic material, etc. they would become an interactive part of the human factors analyses.

c. Benefits: The analyses provides for design incorporation of human factors and safety features. The output of this task also determines the skill levels, training requirements, safety equipment, number of people per task, etc. which are a direct input to the LSAR, as well as the technical manuals.

d. Problems: The task requires inputs as to the physical makeups and clearances of a design. It also requires information regarding the voltages, power levels, toxic and hazardous materials, handles, dials, knobs, etc. This is usually evaluated manually by inspection of drawings and would now require being translated into digitized points and vectors, which is natural to computer-aided drafting as well as computerized analytical techniques. In addition, the output needs to be in a format compatible with text processing for the descriptive material to be used in technical manuals, and a format compatible with numeric manipulation for the LSAR. Both of these requirements need some technical development similar to that required for the reliability, maintainability and testability analyses.

e. Implementation Approach: A three step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is rapidly available with no manual transcription required. The second step would be to develop analytical techniques that are required but not considered to become available in the near future. The second step could also provide for developing government furnished programs that may be made available to suppliers who can not afford to develop or purchase their own. The third step would be to develop the technique, or interfacing Executive, to make the various programs interactive.

f. Implementation Cost: High.

#### 1.6.13 DEVELOPMENT OF PROCEDURES

a. Current Status: Present software programs that can perform this task are limited in much the same manner as the Testability Analyses programs are. Much of this work therefore is still done utilizing manual techniques, which are based primarily on Acceptance Test Procedures used on the shop floor.

b. Target System Characteristics: This task develops the checkout, fault isolation, alignment, and procedures to be used by the built-in-test routine, as well as the support equipment and technical manuals. As the testability analyses programs become more sophisticated, the development of checkout and fault isolation procedures will follow as a natural output of these analyses. This could provide for automated preparation of test programs for automatic test equipment--the BIT, as well as for preparation of step-by-step procedures to be used in technical manuals. A number of limited (in analytical complexity) programs are already available.

c. Benefits: The output of this task is an essential input to the training and technical manual preparation, as well as to the selection of support equipment, and preparation of test and fault isolation procedures.

d. Problems: No problems are envisioned because the inputs to this process are the same as the outputs of the Testability Analyses, and should therefore present very little difficulty in automatic transfer of information from one program to the other, or total interaction of the programs.

e. Implementation Approach: A three step approach is recommended. The first would be to provide for communication between the presently available design assistance and analyses programs such that information is rapidly available with no manual transcription required. The second step would be to develop analytical techniques that are required but not considered to become available in the near future. The second step could also provide for developing Government furnished programs that may be made available to suppliers who can not afford to develop or purchase their own. The third step would be to develop the technique, or interfacing Executive, to make the various programs interactive.

f. Implementation Cost: Low.

#### 1.6.14 VALIDATION/DEMONSTRATION

a. Current Status: This task consists of those validations or demonstrations required by the individual contract. It normally assesses both the accuracy and validity of the analyses performed and then, if required, performs a demonstration(s) of Reliability, Maintainability, etc. The demonstrations are always performed manually on real equipment. If only a validation is required, it is normally performed by review of the results of the various analyses. This task

is usually performed by supervisory personnel, peer level engineers, or customer representatives.

b. Target System Characteristics: Because there is no direct relation to CALS except that the task is usually a prerequisite to the release and utilization of the information resulting from the analyses during the design process, there is no reason to automate it. Nor does this task lend itself to yet another level of digitized analyses.

#### 1.6.15 ASSIMILATE ANALYSES RESULTS

a. Current Status: This task is performed manually. The analyst is normally a high level illities engineer or engineering manager whose approval is also normally requisite to the output reports.

b. Target System Characteristics: Computerized techniques could compare the configuration and source of the information of the various analyses to be combined, so as to make that traceability/cataloging easier for the final analyst. This task would have to remain essentially a manual review and assimilation of the material generated.

c. Benefits: This task collects and assimilates Reliability, Maintainability, and Supportability analyses results and checks for consistency among them. It results in the final reports which are normally required by a contract and, if necessary, provides a coding system that ties the analyses to the equipment configuration. The release of this assimilated information is controlled by its approval process via the validation/demonstration, task 1.6.14.

This task is also the final gate through which outputs of the various analytical techniques must pass in order to input to the LSAR, the spares planning and acquisition, as well as the contractor support planning and acquisition.

d. Problems: The task normally follows the established quality control procedures of a corporation, and as such would differ from company to company. Standardized computerized techniques other than configuration control and data traceability would not serve this task too well.

e. Implementation Approach: None required.

f. Implementation Cost: None.

IDEF A2, CONCEPT PAPER  
FOR  
CALS INFLUENCE ON EQUIPMENT DESIGN

1. FOCUS OF CALS IMPLEMENTATION

1.1 Overview. The principal logistic support functions which relate to those equipment design attributes that influence its support (the supportability attributes) are:

- a. Reliability (1.2.2).
- b. Maintainability (1.2.3).
- c. Safety (1.2.4).
- d. Human Factors (1.2.5).
- e. Packaging, Handling, Storage and Transportability (1.2.6).
- f. Life Cycle Cost Drivers (1.2.7).

1.1.1 Readiness and Sustainability. Each of these place demands on the support resources in terms of their complexity, their quantity, their location and their organizational utilization. This influences the support costs and in turn the sustainability of the equipment. They also influence the operational readiness of the equipment. Although the latter has rarely been linked to logistic support, shortcomings in readiness can be (theoretically) compensated for with an abundance of the proper replacement Line Replaceable Units (LRUs) or, if need be, entire weapons platforms.

1.1.2 Inadequate Analyses and Trades. Life Cycle Cost (LCC) analyses and trades do not usually postulate the alternative of an extra weapon system to make up for the lengthy, difficult, unfixable problems resulting in a reduction in readiness of a platform(s), or "Hanger Queens" (or similar cannibalization "reserves" for the Army and Navy). The cost relationships are very complex and have not yet been worked out.

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REPORT OF THE JOINT INDUSTRY - DOD TASK FORCE ON  
COMPUTER AIDED LOGISTIC (U) INSTITUTE FOR DEFENSE  
ANALYSES ALEXANDRIA VA F R RIDDELL ET AL JUN 85

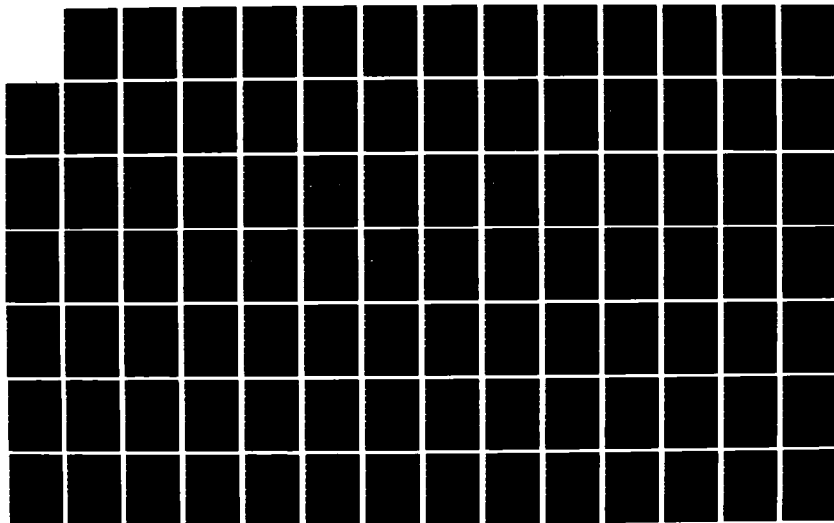
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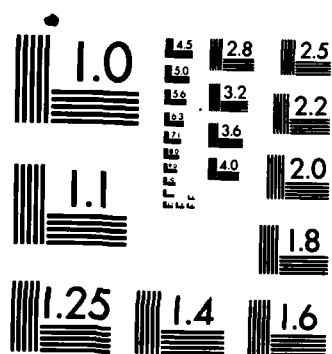
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Because of this, the true cause and effect relationship between specified supportability design attributes (many of which conflict with one another) have not yet been modeled with any degree of credibility. Presently it is believed that the IDA RAMCAD and NSIA MLCAD surveys will indicate that many, if not all, of the important computerized techniques are available to analyze the supportability attributes of a design, but that the interaction between them and the "Big Picture" trades are not yet possible.

**1.2 Projected Performance of the Target Computerized Functions.** The evolution of utilization of computerized techniques for enhancing the supportability attributes of a design has already started by computerizing many of the "illities" existing, normally manually prepared, analytical techniques. Though presently stand-alone and still after-the-fact, they avail the information faster for more timely feedback to the design process. The future holds that these techniques will become interactive with the design process, as described in the paragraphs that follow. They would also become interactive with each other, so that Reliability, Maintainability, etc., analyses results could become truly integrated to provide for the presently unavailable trades between attributes as follows:

**1.2.1 Realistic Trades.** Models will exist which will permit viable trades between performance compromises (including weight and volume) in terms of mission capability, readiness, etc., versus reliability and maintainability compromises, versus cost and schedule compromises, in order to optimize these critical attributes of a design.

**1.2.1.1 Automatic Optimization.** These models would also be designed to perform the above optimization automatically as part of the design process, or as part of an interaction with system/equipment partitioning assessment programs (i.e.,

Performance Simulation, Repair Level Analyses (RLA), Transportability, Maintainability, Testability), to optimize between the logistics concept and performance requirements.

Once the trades are completed and accepted, the models will also be able to apportion and allocate failure rates, built-in-test and maintenance turn-around commensurate with the performance criticality of each of the modules, since these will be known to the program by virtue of the trading parameter.

**1.2.1.2 Integrated Diagnostics and Reliability Centered Maintenance.** It is also anticipated that in less than ten years hence, the automatic modeling and development of trade-off factors for Integrated Diagnostics as well as for Reliability Centered Maintenance will also be completed. Equations and relationships for Reliability Centered Maintenance already exist for manual evaluation. These need only be coupled with the yet to be developed LCC interrelation of readiness and sustainability to provide for viable optimizations of forced removals versus corrective maintenance.

Integrated Diagnostics is still in its infancy as concerns developing factors for optimizing between various maintenance techniques. Industry associations and RADC are working the problem, which presently appears to rely heavily on LCC modeling improvements and the accurate prediction of non-detectable failures or "cannot duplicate" failures. A present trend in improving the capabilities of testability programs hold the promise to provide more accurate predictions of the Figures of Merit (FOMs) for use in the trades.

**1.2.1.3 Additional Benefits.** In addition to the design and data benefits described above and in paragraphs that follow, it is conceivable that many standard planning documents (reliability, maintainability, ILS plans, etc.) and technical reports (prediction reports, LCC reports, FMECA reports, etc.) can be replaced by direct access to the information that resides in the design and analyses data bases.

**1.2.2 Reliability.** Once the initial spares and support resources have been acquired, virtually all recurring support costs (replenishment spares, touch labor, test equipment utilization, etc.) are directly, and in most cases linearly, related to the reliability of an equipment and its components. Reliability requirements are usually specified with regard to what has been attained in similar equipment or, if properly thought out, what is really required in terms of the function or mission of the equipment, considering the maintenance capabilities and philosophies. The future holds that:

**1.2.2.1 Field Data Collection Improvement.** Actual field data will be collected, sorted and analyzed in such manner that reliable, meaningful data of the "Comparison System" (DoDD 5000.39) will be available on-line to the specification preparation team during the preparation of the reliability requirements for the new system/equipment, in terms of its required performance functions, allowable degradations, and critical mission requirements.

**1.2.2.2 Design Rules Preparation.** Actual field data will be reduced to Lessons Learned for the Comparison System, or general design application, and stored in Design Rules Libraries that are accessed automatically and transparently in the same computer in which the design is evolving (CAE/CAD), much like a spelling checker is accessed in word processing, except automatically. The library would be continuously updated from test experience and field data.

Subroutines or linked programs could evaluate the consequences or benefits of rejecting or accepting the rules in terms of Equipment Reliability, Life Cycle Cost, Mission Success, and similar FOMs in short order for use by the design review/approval team. These results would be available to the designer for final decision.

Likewise, the computer could perform the optimization automatically, permitting the designer to also test various different design options.

**1.2.2.3 Standardization of Models.** The many reliability analyses models that are available today as stand-alone models would be standardized and approved for use in terms of how they address existing (manual) government-specified and industry-accepted techniques. These approved techniques would then interact automatically with the development of a design, via computerized design techniques, in such manner that the information is available to the designer during the design process to enable him, rather than a second or third party, to rectify problems and optimize the reliability of the item being designed.

**1.2.2.4 Meaningful Failure Rates.** Reliability analyses would provide meaningful failure information (in terms of original performance requirements as developed from the system/equipment level trades) at the input/output boundary of the item analyzed in order to develop fault detection/isolation techniques such as Testability Analyses, Automatic Test Program Generators, and Sneak Circuit Analyses. The output would then also feed the Integrated Diagnostic program, once developed.

**1.2.2.5 Stress Considerations.** Existing stand-alone models that consider component/structural member/machinery stress (electrical and/or mechanical) during the range of environmental and performance demands will be linked closer to, if not interactively with, the computer-aided design engineering process. This will provide for more wide-spread utilization by the designer due to its timeliness, as well as provide an opportunity for streamlining design reviews.

**1.2.2.6 Streamlined, Cost-Effective Design Reviews.** It is envisioned that computerized techniques could be qualified and

approved much like accounting techniques, mathematical techniques for analyzing performance, or predicting behavior-based physical and mathematical rules, etc. such that once approved, it would suffice to establish that the approved design analysis technique was employed for a particular design and it resulted in the design's approval.

**1.2.2.7 Interaction with Other Techniques.** Outputs of the reliability models would be structured so as to interact with dependent programs, such as maintainability, and directly input to the LSAR or similar support resource planning analyses and documentation.

**1.2.2.8 Elimination of Data Items.** Classic manually produced data items will be eliminated, and all reliability related data will be available from a data bank, and/or the LSAR. These would be accessed (with proper security in place) by authorized personnel, via terminals, for their application in CALS.

**1.2.3 Maintainability.** Maintainability requires two distinct design attributes. Those related to fault detection and isolation (testability attributes), and those related to the correction of the fault (repairability attributes). Both require expensive support resources in the form of tools, test equipment, manpower, training, and technical manuals which get multiplied by the number of repair sites and their manpower and shop loading. Spares and repair material requirements are normally attributed to the reliability of an item. However, such a plan holds only if there are no mistakes made, nor damages inflicted during maintenance. Classically, spares and repair material projections do not consider battle damage.

Experience, particularly with electronic equipment, indicates large problems in spares depletion due to errors in diagnosis at all levels of maintenance. Errors stem from Built-in-Test, Automated Test Equipment, poor instructions, inadequate

training, technician errors, or damage inflicted during maintenance. These all relate directly to the techniques employed for, and timeliness of, analyzing the testability of a design and preparing test programs and instructions from the results. The results are the failure to meet readiness and supportability objectives, extremely high, usually unanticipated support and support related data costs, and severe restrictions on optimizing the maintenance concept for the equipment.

Repairability problems exist in both electronic, and to a greater degree, mechanical/structural designs. These relate largely to repair accesses, repair difficulty, poor structural modularization and anthropometric issues. These in turn relate directly to the techniques employed for, and timeliness of, analyzing the repairability aspects of a design and preparing modularization, accessibility, fastening, connecting, etc. optimizations/trades; designing accordingly; and preparing appropriate instructions from the results.

In addition to the previously discussed field data feedback and viable trade models, the future for maintainability techniques holds that:

#### **1.2.3.1 Greatly Improved and Design Interactive Techniques.**

Presently there are many stand-alone maintainability analytical programs available which will perform the testability as well as repairability analyses with varying degrees of thoroughness, and complexity, and inputting programs such as reliability, FMECA, LCC, etc. There are also anthropometric models being developed.

Just as for reliability, the many maintainability analyses models would be standardized and approved for use in terms of how they address existing (manual) government-specified and industry-accepted techniques (barring the introduction of better techniques, i.e., for testability). These approved techniques would then interact automatically with the development of a

**1.2.3.3 Streamlining the Design Review.** It is envisioned that just as for reliability, computerized techniques could be qualified and approved for their application such that, once approved, it would suffice to establish that the approved design analysis technique was employed for a particular design and it resulted in the design's approval.

**1.2.3.4 Program Interaction.** Outputs of the maintainability models would be structured so as to interact with dependent programs such as repair level analyses, life cycle cost analyses, transportability analyses, test program generation, technical manual repair procedures, maintenance task analyses, manpower and skill analyses, spares and repair parts identification and SMR coding, and support equipment analyses, and would be directly input to the LSAR or similar support resource planning analyses and documentation.

**1.2.3.5 Elimination of Data Items.** Classic manually produced data items will be eliminated, and all maintainability related data will be available from a data bank, and/or the LSAR. These would be accessed (with proper security in place) by authorized personnel, via terminals, for their application in CALS.

**1.2.4 Safety.** Although safety is an important design consideration for operation and maintenance of an equipment, it is also an important consideration in product liability, and has received considerable attention from that aspect. It is not considered a prime candidate for improvement in Reliability, Maintainability and Supportability. The rules checking for safety features and dangerous items/conditions will eventually become part of the commercially available CAE programs by virtue of demands made by the private sector, which has a greater exposure to product liability and as well as competition for user acceptance.

**1.2.5 Human Factors.** Those human factors considerations that place demands on skill and experience for maintenance are handled

by maintainability, wherein the analytical techniques discussed there would serve to optimize the demands placed on the technician as well. Human factors considerations for operation, manipulation, and maintenance access relate to the anthropometric analyses which are being actively developed now. Costs relating to the technician, his training, rotation, sustenance, and maintenance aids are a significant part of an item's support cost. The future holds that:

**1.2.5.1 Design Interactive Analyses.** Human factors analyses will be performed in three areas. First, within the CAE program itself to take care of operational anthropometric considerations. Second, within the maintainability programs to take care of at least the difficult maintenance actions. Third, in separate anthropometric modeling for access and repair/replacement.

**1.2.5.2 Use of Field Data.** As in reliability and maintainability, actual field data will be used for lessons learned input to the computerized rules checking. However, the actual analyses regarding time, skills and resources will be part of the maintainability analyses, rather than another stand-alone module. Interpretations and tradeoffs between design features to accommodate human factors will remain manual tasks, with the computer assisting only in the calculations.

**1.2.5.3 Battle Damage Assessment Interaction.** Anthropometric maintenance modeling presents the opportunity for modeling battle damage situations, if it were interrelated with the design program. It is assumed that this will happen by virtue of its importance. Support Cost advantages however, will not be predictable until the operational readiness or availability analytical models are ready to equate results to support costs. It is suggested that this must happen first as part of the Life Cycle Costs modeling, in order to predict the seriousness of the



lack of attention to battle damage, as well as the return on investment for the development of the design, and design information interrelation.

Presently, LSARs do not collect battle damage maintenance demand data. The output of the above analyses would therefore require changes to the LSAR, or a separate data base. It is assumed that the latter will be developed, due to the specialized nature of the input information and application of the results of subsequent analytical processes.

**1.2.6 Packaging, Handling, Storage and Transportation.** Except for very special situations, i.e., large items, or dangerous handling, this is not a support cost driver. However, it has normally not been considered in equipment division. The future holds that:

It will continue to be performed manually.

Maintainability partitioning and repair level analyses programs will include PHST issues which will then be input to transportability models (manual).

The outputs of the transportability modeling will be formatted so as to directly input to the LSAR.

**1.2.7 Life Cycle Cost Drivers.** The design features that affect life cycle costs to a significant degree are as follows, in the order of effect on present modeling considerations:

Reliability

Acquisition costs (spares)

Standardization

Support Equipment and attendant costs

Manpower costs

Direct repair labor costs

Etc.

The above issues are not normally related to independently variable design attributes. To the contrary, they usually constitute conflicting design considerations. Therefore, in order to achieve the lowest LCC, trades/optimizations are required between these design related issues. This requires LCC modeling that has been sensitized to changes in one design attribute or another so that the effect on changes to a "same color money" cost to the government can be properly assessed. In addition, to be of any value in design influence, the trades must be performed at such a time that the large drivers, rather than the inconsequential ones can be changed. The future holds that:

Trades between design attributes will include LCC considerations and will be performed at the same time that reliability and maintainability analyses are performed, so as to interact with the design process.

Life cycle cost models will include proper quantifiers for availability/readiness, as well as true government overhead costs for material, equipment and labor.

Life cycle cost will become a serious contractual issue, second only to acquisition costs; and trades will become the tool of the program manager and design engineer, as opposed to the illities engineer. This is already evident in highly competitive commercial items such as automobiles and aircraft.

### **1.3 Implementation Considerations.**

**1.3.1 Technical Considerations.** The major technical software design problems are either in the process of being solved (i.e., anthropometric modeling), or have already been resolved in stand-alone programs which have been designed primarily to digitize

accepted and customarily specified analytical techniques. The implementation considerations remaining then, are:

**1.3.1.1 Things to be Developed:**

- a. Credible and usable field data collection, sorting and feedback for inputs to reliability, maintainability and other lessons learned computerized libraries.
- b. Development of models (or modifications) to address availability and readiness in terms of support costs for trade models (i.e., LCC).
- c. Development of proper cost factors for LCC so that all items contain correct overhead burdening for equivalent cost factors.
- d. Development of models which will permit viable trades between performance compromises and reliability, maintainability and supportability.
- e. Modeling of Integrated Diagnostics as a trade-off tool for fault detection/isolation techniques and requirements at various maintenance levels.
- f. Techniques for interaction with CAE/CAD.
- g. Techniques for communications/interaction between analytical techniques, the LSAR, and the data users.
- h. Techniques for computerized development of detailed specifications and work statements that properly address reliability, maintainability and supportability requirements, commensurate with the use and maintenance scenario of the weapon.
- i. The modeling of integrated diagnostics and reliability centered maintenance.
- j. Battle damage assessment and repair action analyses and instructions.

1.3.2 Contractual Issues. The following are non-technical issues that require consideration in specifications, statements of work and contractual terms and conditions:

a. What is required to have a developer improve reliability, maintainability and/or supportability of an equipment that already meets the contractual requirements. What contractual issues are involved.

b. What would incentivize or otherwise require a developer to utilize these techniques. What contractual issues are involved in this and in data preparation/delivery/user-utilization.

c. What would be the contractual considerations to require a developer to properly address built-in-test and testability.

d. What are the end bounds for the trading of performance, weight and volume requirements against reliability, maintainability and supportability design features.

e. What are the issues of warranties and product performance/safety liabilities.

f. Where lies the responsibility for battle damage workaround.

g. What are the security/proprietary issues of computerized interfacing and design review.

1.3.3 Integration Issues. Integration of the reliability and maintainability computerized models with CAE/CAD programs appears difficult in light of the progress made with independent, commercially available programs for these interdependent techniques. The possibility of interfacing in some rapid manner, rather than real-time, should be considered. Certainly that would be quicker than any presently available technique where a different (from the designer) discipline performs the analyses. Even though the turn-around time has been reduced to acceptable levels by computerized techniques, it is still:

a. Subject to the classic "not invented here" rejections by the designer.

b. In series with the completion of a design, even if the design is in digitized, not-yet-drawn, format. Consequently, it would require a costlier change than if interactively prepared by the designer himself.

c. The present direction of computerized design is towards a paperless information transfer from design to machining. The information that is being transferred in this manner is not usable for reliability, maintainability, supportability, testability, technical manuals or LSAR inputs. Intermediate products compatible with the input requirements of these will have to be provided. To be considered:

(1) Pictorial information rendered for inclusion in technical manuals.

(2) Parts listings, numbering and used-on information from the bill of materials for use in parts lists and provisioning documentation.

(3) Numbering systems compatible with LSAR numbering systems.

(4) Information from the field of drawings (dimensions, values, nomenclatures, pin assignments, etc.) for use in technical manuals and for testability programs, test program generators and support equipment requirements.

#### **1.4 Likely Payoffs and Benefits.**

**1.4.1 Preliminary Assessment of Stand-Alone Techniques.** The potentials available from employing stand-alone computerized analytical techniques for reliability, maintainability and supportability analyses are already known. The techniques have

resulted in quicker, more thorough and accurate analyses, and have as a minimum provided for:

- a. Correction of major design problems.
- b. Improvement in testability.
- c. Preparation of better test programs.
- d. Paved the way for integrated diagnostic trades/modeling.
- e. Improvement in reliability stress modeling, thereby providing designs more capable of meeting specified requirements.
- f. Improved acceptance of results by illities engineers and designers.
- g. Government sponsored demonstrations of feasibility and advantages of the techniques to provide design improvements.
- h. IR&D investment by many large firms in utilization and development of analytical techniques for their particular application.

#### **1.4.2 Preliminary Assessment of Interactive Techniques.**

Presently the techniques for utilizing the information available from the computerized analyses have not changed from that of manual techniques, in that data are still transferred manually from one user (person or program) to another. There is still much duplication in analyses and data products preparation, and design engineering acceptance, though improved, falls short of a more desirable design engineer's utilization of the techniques.

By combining or interacting some of the more critical reliability, maintainability and supportability analyses with the CAE/CAD employed by the designer, the designer himself would be directly interacting with the assessment and development of optimized R,M&S design attributes. Communicating between the programs would be automatic and require no transcription. Some of the major benefits would be:

a. Greater innovation in obtaining reliable and supportable equipment beyond the specified requirements, thus improving readiness and sustainability. It would also become possible to specify and obtain more stringent R,M&S requirements.

b. Reduced development costs.

c. Reduced manufacturing costs by eliminating corrective redesign.

d. Reduced manufacturing costs by virtue of providing testability and ease of maintenance design attributes which also result in quicker assembly line testing and assembly of an item.

e. Elimination of manual data preparation practices, thus reducing data costs by orders of magnitude.

f. Provision of accurate analytical data traceable to the design features and design configurations.

g. Elimination of duplicative efforts by providing direct inputs to the LSAR, spares documentation and technical manual preparation.

h. Potential for eliminating all paper data by transferring only the elemental information from which data products are normally prepared.

i. Potential for remote design reviews.

j. Potential for use by subtiers and small firms who develop less than major systems and subassemblies whose reliability, maintainability and supportability nonetheless have significant impact on the weapon's readiness and sustainability.

## **1.5 Changes Needed and Problems.**

**1.5.1 Changes Needed.** Besides the implementation considerations of paragraph 1.3, it is thought that the most important and cost effective resulting recommendation for change

to the present way of doing business is the structuring of an RFP and Performance Specification utilizing (as yet to be developed) computerized techniques to guard against omissions, and to assist in and provide assurance of the inclusion of specifically tailored R,M&S related design requirements.

**1.5.2 Anticipated Problems.** Some of the problems beyond those enumerated in paragraphs 1.3 and 3. are:

a. The utilization of the computerized techniques by prime contractors, i.e., weapon platform manufacturers without their subtiers' utilization of comparable or even compatible techniques. This would be especially troublesome if the subtiers' equipment is the reliability, maintainability or life cycle cost driver.

b. Prime contractors' failure to pass incentives and other contractual benefits to the subtiers who are utilizing/developing computerized techniques.

c. Reluctance by data users to adapt to modern data transfer and information presentation.

d. Reluctance by design review teams to accept an analytical program's design approval. This would have the potential of duplicating computerized techniques manually to establish confidence.

e. The eventual evolvement into a no-hardcopy-backup situation.

f. How to check/validate a computerized technique as to accuracy, completeness and freedom of glitches.

## **2. IDENTIFICATION OF CANDIDATE FUNCTIONS**

**2.1 Candidates for Automation.** All of the presently specified reliability, maintainability, repair level and life cycle cost models should be automated. Most of this has already taken place with computerized models commercially available. Some are



available as GFE. It is suggested that all be made available as GFE to companies that do not have these techniques in place. In addition, the following should be developed:

- a. Analyses for readiness and sustainability.
- b. Automatic techniques for specification preparation.
- c. Spares cost projections for input to LCC and LSAR.

**2.2 Candidates for Standardization.** All of the presently specified reliability, maintainability, optimum repair level and life cycle cost models that are automated should be standardized against the attendant specification in the same manner that manual techniques are. Data dictionaries for input and output data structure and labels must be standardized to enable communication between programs and users. The standardization must consider the MIL-STD-1388-2A Data Dictionary.

**2.3 Candidates for Integration.**

**2.3.1 Integration with CAE/CAD.** The following generic analytical techniques should be integrated with CAE/CAD:

- a. Reliability:
  - Parts failure rate catalogue
  - Lessons learned failure rate/parts application feedback
  - Preferred parts lists
  - Parts/material application
  - Parts tolerance analyses
  - Stress analyses, electrical, thermal, vibration, etc.
  - Predictions
  - FMECA
  - Allocations to lower assemblies
- b. Maintainability

Sneak circuit analyses  
ATE compatibility analyses  
Testability analyses (includes BIT)  
Elemental maintenance actions catalogue  
Lessons learned maintenance task difficulties  
Maintenance access  
Predictions

- c. Other
  - Life cycle cost analyses
  - Readiness/availability analyses
  - anthropometric analyses

**2.3.2 Integration with Each Other.** The following generic analytical techniques should be integrated with each other:

- a. All the techniques of 2.3.1.
- b. Reliability
  - Mission reliability predictions
  - Construction of reliability diagrams
  - Construction of functional block diagrams
  - Reliability centered maintenance analyses
  - Reliability risk analyses
- c. Maintainability
  - Integrated diagnostics analyses
  - Level of repair analyses
  - Maintenance task and skill analyses
- d. Other
  - PHST analyses
  - Spares cost projections

### 3. ANTICIPATED RECOMMENDATIONS

3.1 Funding Issues. It is anticipated that recommendations will involve matching funds for IR&D and/or development funds if requirements for computerized techniques are specified in a contract.

3.2 Incentive Issues. Incentives will have to be addressed if the desired result for using computerized techniques is to provide better than specified equipment, reducing data costs and support resource costs.

3.3 Contracting Issues. The use of computerized techniques would reduce the manpower required to perform analyses, prepare data, etc., thus reducing the overhead base of a company's fee structure. New regulations and contracting techniques will have to be developed to compensate for this.

3.4 Competitive Issues. The specifying of reliability, maintainability, supportability, analytical techniques, etc. in an RFP will provide the tremendous advantage of competition leverage such that competing contractors will of themselves implement the computerized techniques in order to be responsive as well as competitive. THIS IS THE SINGLE MOST COST EFFECTIVE TECHNIQUE FOR THE GOVERNMENT TO CAUSE INDUSTRY TO UTILIZE CALS!

3.5 Specification and Standards Issues. Specification and standards issues must be addressed prior to any other issue due to the proliferation of independent, stand-alone models, as well as the need to have many of these interface/interact with each other, the users and reviewers.

It is expected that an interim measure will be recommended in which it will be suggested that existing standards for manual techniques be changed to permit computerized techniques. This would be the simplest way to get things started.

**3.6 Technological Changes.** It is expected that technological changes for information transfer between programs will be required.

**3.7 System Characteristics.** The issues of security, concern of data loss and unauthorized manipulation, rights in technical data and proprietary techniques, untimely review and similar concerns range uppermost in industry and will have to be addressed in contractual and well as policy issues.

**3.8 Policy Issues.** Present DoD Policy, i.e., 5000.39, already provides that the R,M&S issues of a system be addressed during design, without specifying the technique. Therefore, the computerized techniques are responsive to that policy without change. However, it is expected that recommendations regarding incentives, contracting and the issues of security and proprietary rights will require new or changed policies.

#### **4. JUSTIFICATION FOR THE CHOICE OF CANDIDATES**

**4.1 High Payoff.** As previously discussed, the reliability and maintainability candidates provide the opportunity for high payoff in terms of readiness and sustainability, as well as lower costs for development, manufacture and data preparation.

**4.2 Feasibility.** The fact that most of these computerized techniques are already available and some are being demonstrated for value in design improvement attests to their feasibility. Many programs are already interactive, indicating the feasibility of communications. Progress in interface specifications for CAD to CAM and pictorial to text processing indicate that interfacing/interacting with CAE/CAD techniques is also feasible for the reliability, maintainability, PHST and life cycle cost driver target functions.

4.3 High Leverage. The reliability, maintainability and life cycle cost driver analyses are the principal functions which will identify the design attributes required for optimizing readiness and sustainability of the equipment. They are also the principal generators of the design and support information necessary for the development support plans, technical manuals, training material and plans, spares recommendations and coding, and all other support resources.

CALS FUNCTIONAL DESCRIPTIONS  
CONTRACTOR FUNCTIONS:

4. IDEF A22, Perform Allocations



## A22 Perform Allocations

There are six activities which describe the allocations process. Starting the diagnostic procedure at all maintenance levels is the first of these activities. This is a rough cut procedure for fault detection and fault isolation. For example, prior to performing any other trades, modern electronic design is structured to result in functional packaging in order to facilitate fault detection and fault isolation. Fault detection and isolation times are then proportionately divided among these modules.

Equipment partitioning is the second activity which provides the division of equipment or assembly into its next lower level of assembly. It utilizes the test node information from the diagnostic procedure, as well as the RLA to perform this task. The model(s) would automatically optimize between division for the sake of testability (functional), packaging and transportability, cost (standardization and multi-application), performance, etc. as part of the design process.

The third activity is the establishment of reliability allocation. This provides the allocated MTBF to the module as it has been partitioned, as well as narrows the selection of preferred parts to be used in the design of the module. The search of the parts library as it is done today could possibly be improved in that the process of designing a performance of an item could very well narrow down the range of parts that could provide that performance, and with that prescreening could save a considerable amount of time. Also if done properly the prescreening could result in the parts listing to be contained on the drawing's bill of material automatically, as well as be provided in text processor format for use in editing into parts lists and LSAR inputs.

Activity four is the conducting of trades. This activity provides for optimizing Reliability, Maintainability, Supportability, Design and Maintenance Concepts during the allocation process. Future trades however, would also model readiness and sustainability, as well as the effects on transportability. The latter would be modeled in such a way as to interact with the equipment partitioning or modularization of the equipment being designed, which in turn would interact with the maintainability allocations and reliability allocations.

Maintaining allocations is the fifth activity. This provides the allocated MTTR to the module as it has been partitioned. It also serves to separate task times between testing tasks, remove and replace tasks, and repair tasks. The development of the partitioning program(s) would automatically provide the MTTR apportionment, and no further, special development for this apportionment will be required.

The last activity is providing firstcut Failure Mode Effects and Criticality Analysis (FMECA). This tests the equipment partitioning from a standpoint of assessing the effect and propagation of functional failures. It identifies problems in performance degradation, fault detection, fault isolation, as well as critical failures and parts. Its function in the allocation process is primarily of optimizing the equipment partitioning, identifying potential design problems, and attempting to prevent the use of critical components and circuits. There are digital techniques available



A22 Perform Allocations (Con't)

but these are usually used when design information is available during the analytical process.

Glossary

Specified Technique - Analytical methods as specified by contract.

Testing - To check performance by test.

BIT FOMS - Built-In Test Figure of Merit.

Detection/Isolation FOM - ie detection ratio, fault isolation ratio.

Skill - Skill requirements for the maintenance task.

Maintenance Philosophy - Description of how maintenance is to be performed.

Performance - The operating requirements of the system.

Manual - Performed manually as opposed to automatically or computerized.

Test Times - Time to perform an elemental test.

Ambiguities - Identification of more than one probable cause for a malfunction.

Test Nodes - Circuit junctives at which testing is to be performed.

Module Perb. & Size - Module performance and physical size.

RLA - Repair Level Analysis.

Maintenance Phil., Skill, Performance, Target Support, Cost, Overall  
MMH/OH - Maintenance/Manhour Operating Hour.

Skills, Manpower, MTTR - Mean Time to Repair.

Preferred Parts - A listing of parts of first choice for design.

MTBF - Mean time between failures.

Parts Library, Performance, Overall MMH/OH - Maintenance manhour per  
operating hour.

Size, Weight PHST - Packaging, Handling, Storage and Transportation.

Defined Degrees of Freedom - Allowable deviations from the specified norm.

Test Points - Circuit locations at which to perform measurements.

Critical Parts - Parts whose failure cause serious or dangerous system  
problems.

Ambiguities, Bit Problems - Built-In Test.

Table 2-9. IDEF A22, CONTRACTOR (sheet 3 of 3)

A22 Glossary (Con't)

LCC - Life Cycle Cost.

Perform, Risk - Risk in attaining required performance.

Transportability - Requirements for transporting an item of equipment.

Readiness Sustainability - Figures of merit to measure system operational readiness and to keep it operationally available.



CALS FUNCTIONAL DESCRIPTIONS  
CONTRACTOR FUNCTIONS:

5. IDEF A24, Perform Analyses

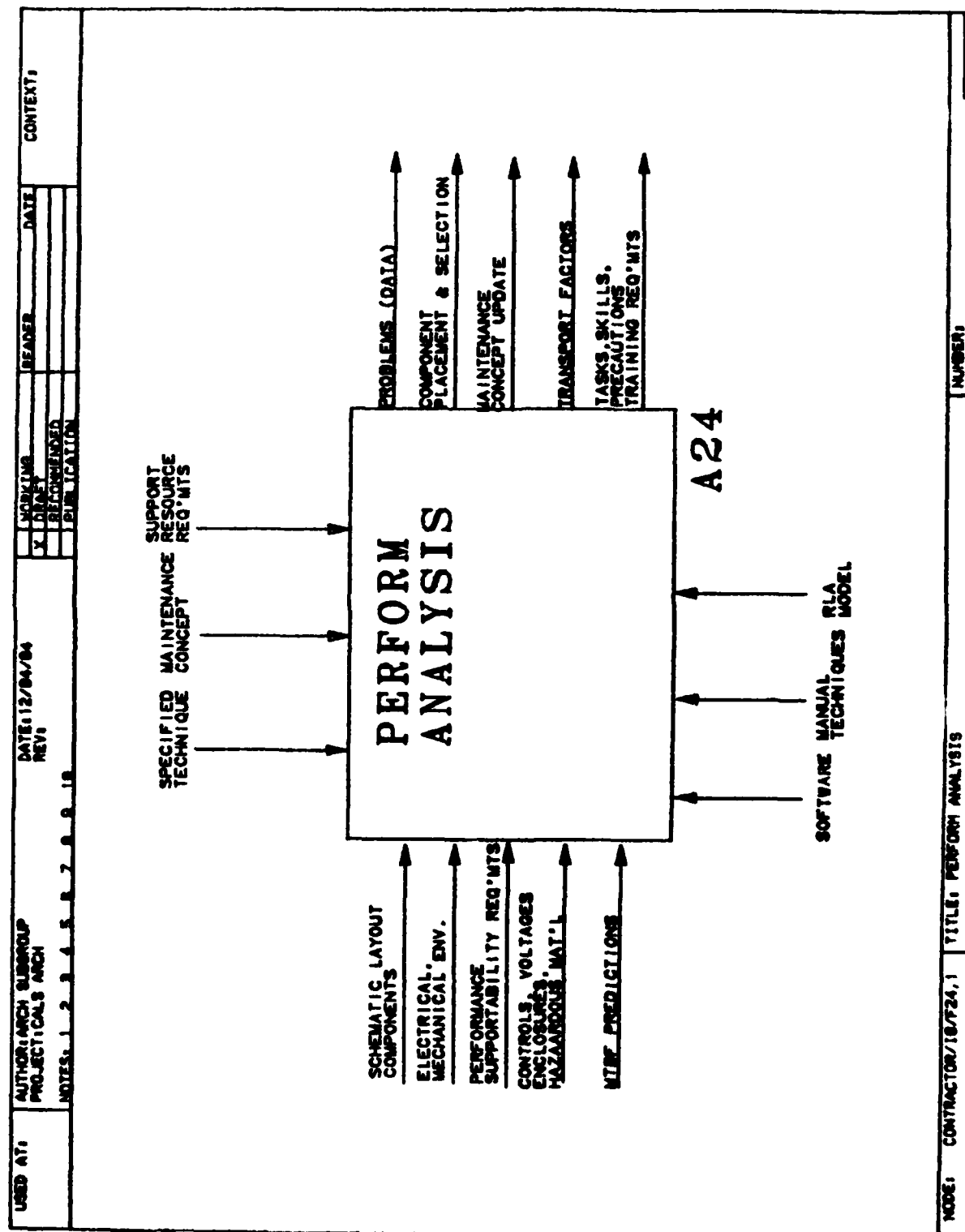


Figure 2-9. IDLF A24, PERFORM ANALYSES, CONTRACTOR

Table 2-10. IDEF A24, CONTRACTOR (sheet 1 of 2)

#### A24 Perform Analyses

The performance of analyses consists of six activities. Reliability stress analysis is the first of these activities. This analyzes a proposed design to determine the effect of stress on the performance and reliability of that design. The analysis requires detailed design information. Electrical design and component information is required to perform electrical stress analyses. The thermal stress analyses apply to parts location information. Ambient/cooling air information is required for thermal stress analyses.

An environmental profile, together with mechanical layout and packaging information is required to perform environmental stress analyses, which could range from temperature and mechanical shock to vibration and other mechanical stresses on the components, as well as the chassis or circuit board upon which these are mounted. The assumption is that all this information will be available to the analytical techniques of the future, such that these analyses could be performed interactively with a CAE/CAD program.

Testability analysis is the second activity. This activity analyzes a circuit to determine whether or not it is testable for all its performance attributes with the test facilities that are resident in the circuit. There are two major approaches to this. One is a by-product of a circuit analyses for purposes of determining its capability to perform its intended function, which is sometime labelled a sneak circuit analyses, or circuit performance analyses. The other is a purely statistical technique. The statistical technique will only provide a figure of merit, whereas the detailed analyses will actually provide information for test point placement, as well as the development of fault isolation procedures.

The third activity is providing FMECA. This provides the failure modes, effects and criticality analyses of the item being designed, as well as of its next higher level of assembly from inputs provided it automatically from the design process, and the results of the reliability and testability analyses.

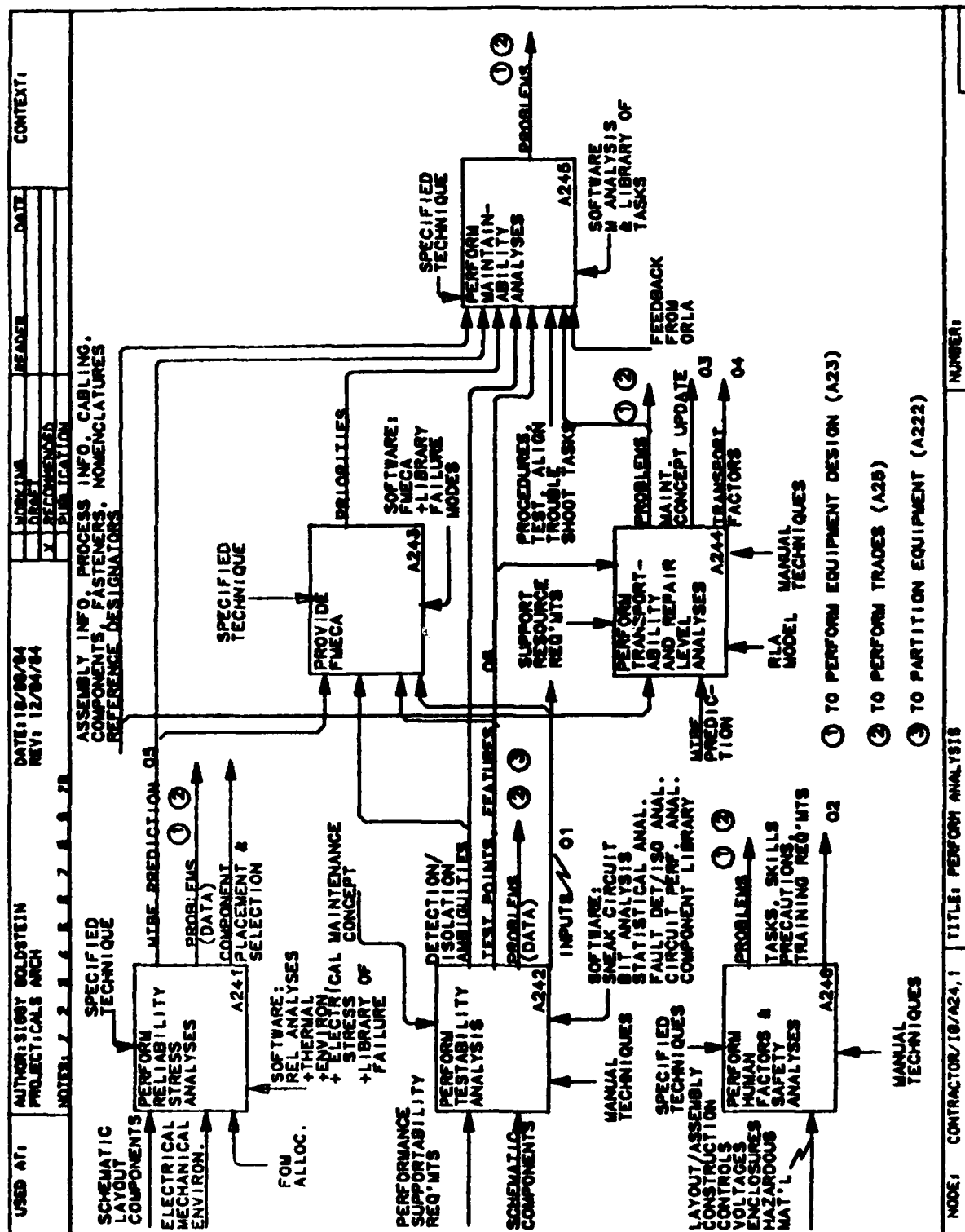
Transportability and repair level analyses comprise the forth activity. this seeks to ascertain the most economical maintenance and maintenance level of the item in question. It uses life cycle cost modeling with which to test the cost effectiveness of each maintenance concept evaluated, including that of discard. The target system would provide for automatic inputting to the model, as well as its interaction with the other models.

The fifth activity is maintainability analysis. This prepares the Maintainability Analyses of a design. The final, detailed Maintainability Analyses require input from the Reliability Analyses, the Testability Analyses, the Test Procedures, the FMECA and design information in terms of the assembly, cabling, assembly process, components and component placements, fasteners, nomenclatures, and reference designators. Feedback from the Repair Level Analysis, if performed, is also required.

Table 2-10. IDEF A24, CONTRACTOR (sheet 2 of 2)

**A24 Perform Analyses (Con't)**

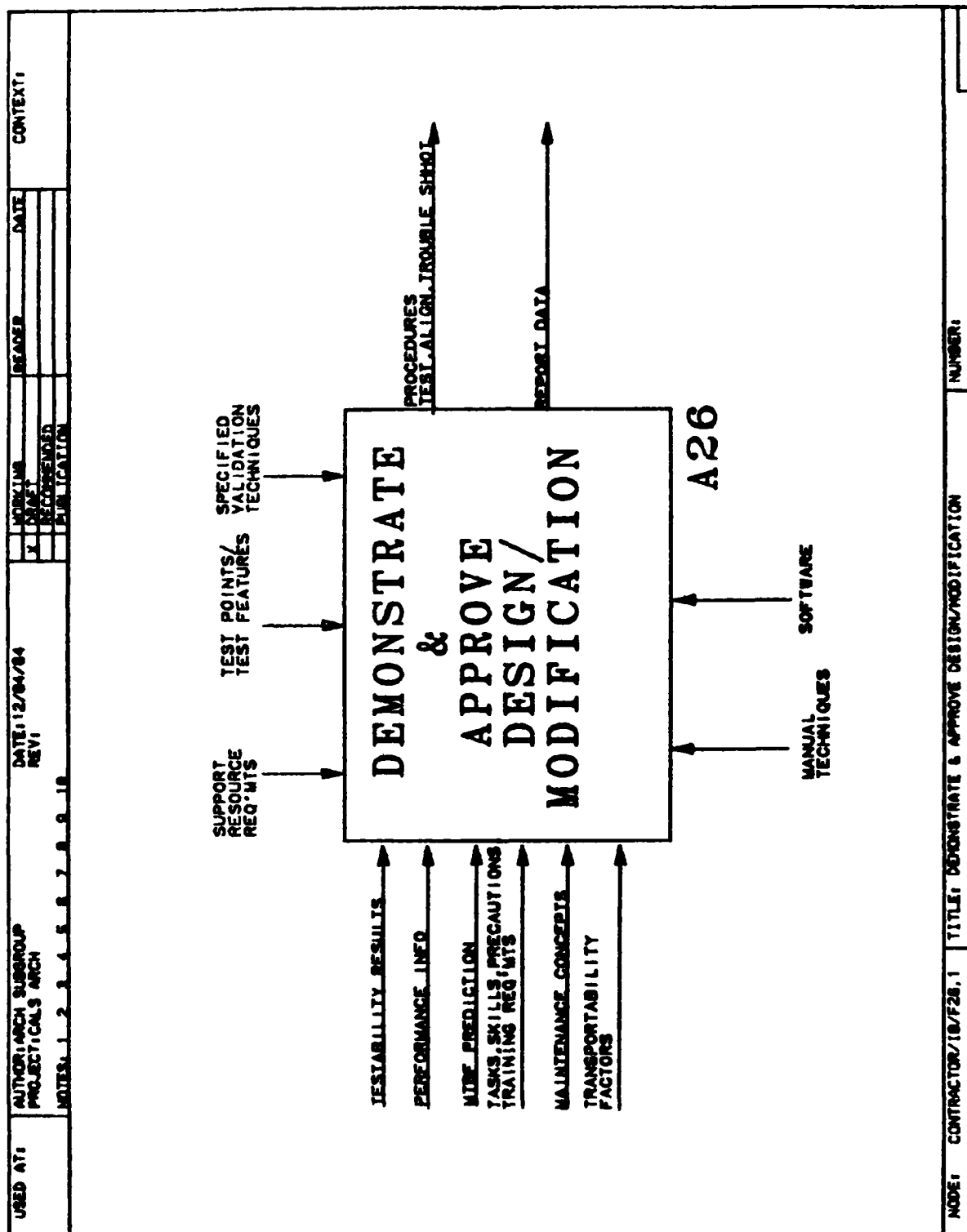
The last activity is the performance of human factors and safety analyses. This analysis will automatically analyze the design from the standpoint of work access and other anthropometric considerations. It will, together with the Maintainability Analyses, determine the task and skill requirements, as well as training requirements of the maintainer and operator. Since the Safety Analyses are closely linked to the Human Factors Analyses and ascertain dangerous voltages, power levels, hazardous tasks, sharp edges, toxic material, etc. they would become an interactive part of the human factors analyses.





CALS FUNCTIONAL DESCRIPTIONS  
CONTRACTOR FUNCTIONS:

6. IDEF A26, Demonstrate and Approve Design/Modification



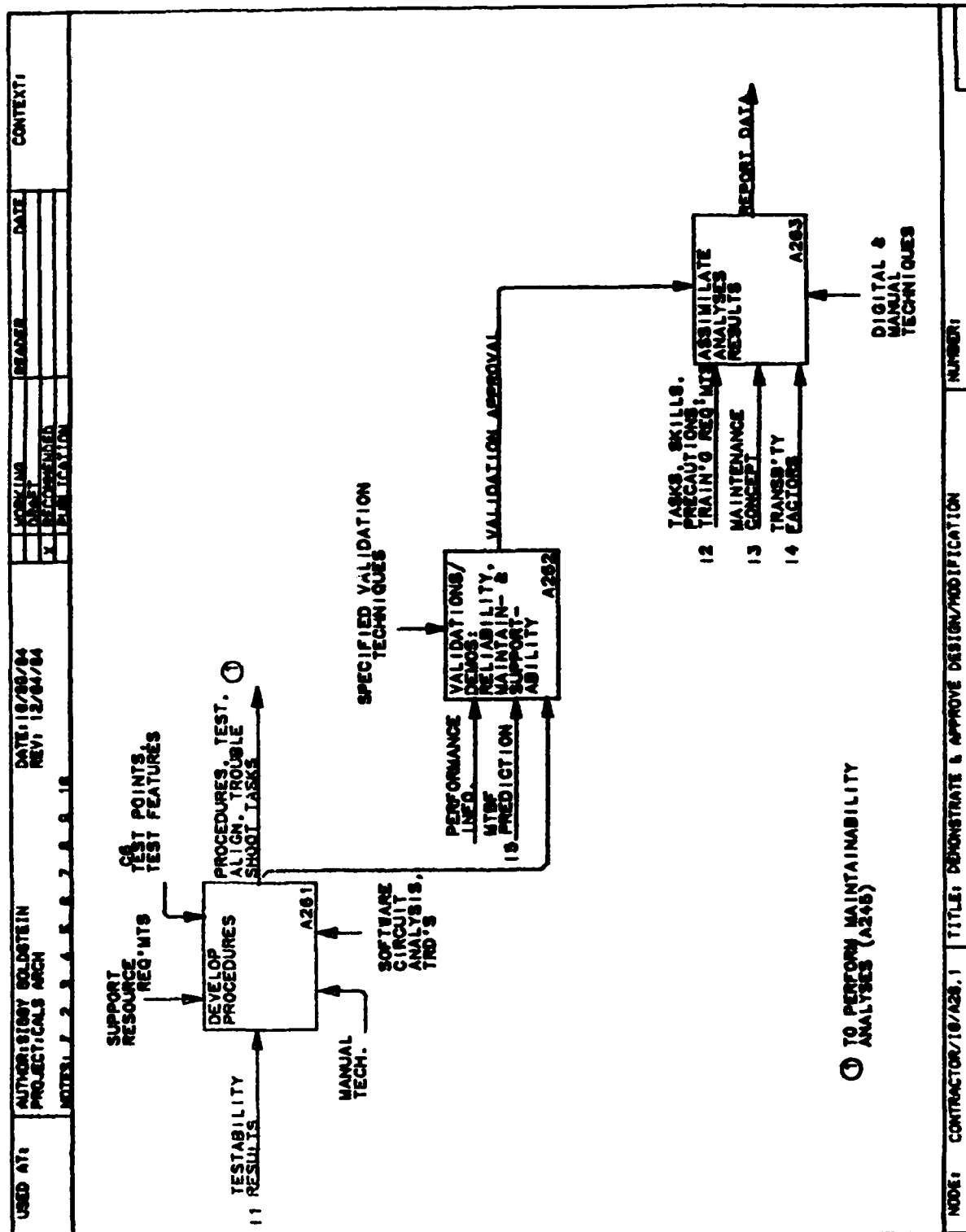


Figure 2-12. IDEF A26n, DEMONSTRATE AND APPROVE DESIGN/MODIFICATION, CONTRACTOR

**CALS FUNCTIONAL DESCRIPTIONS**  
**CONTRACTOR FUNCTIONS:**

**7. IDEF A3, Provide Logistics Resources**

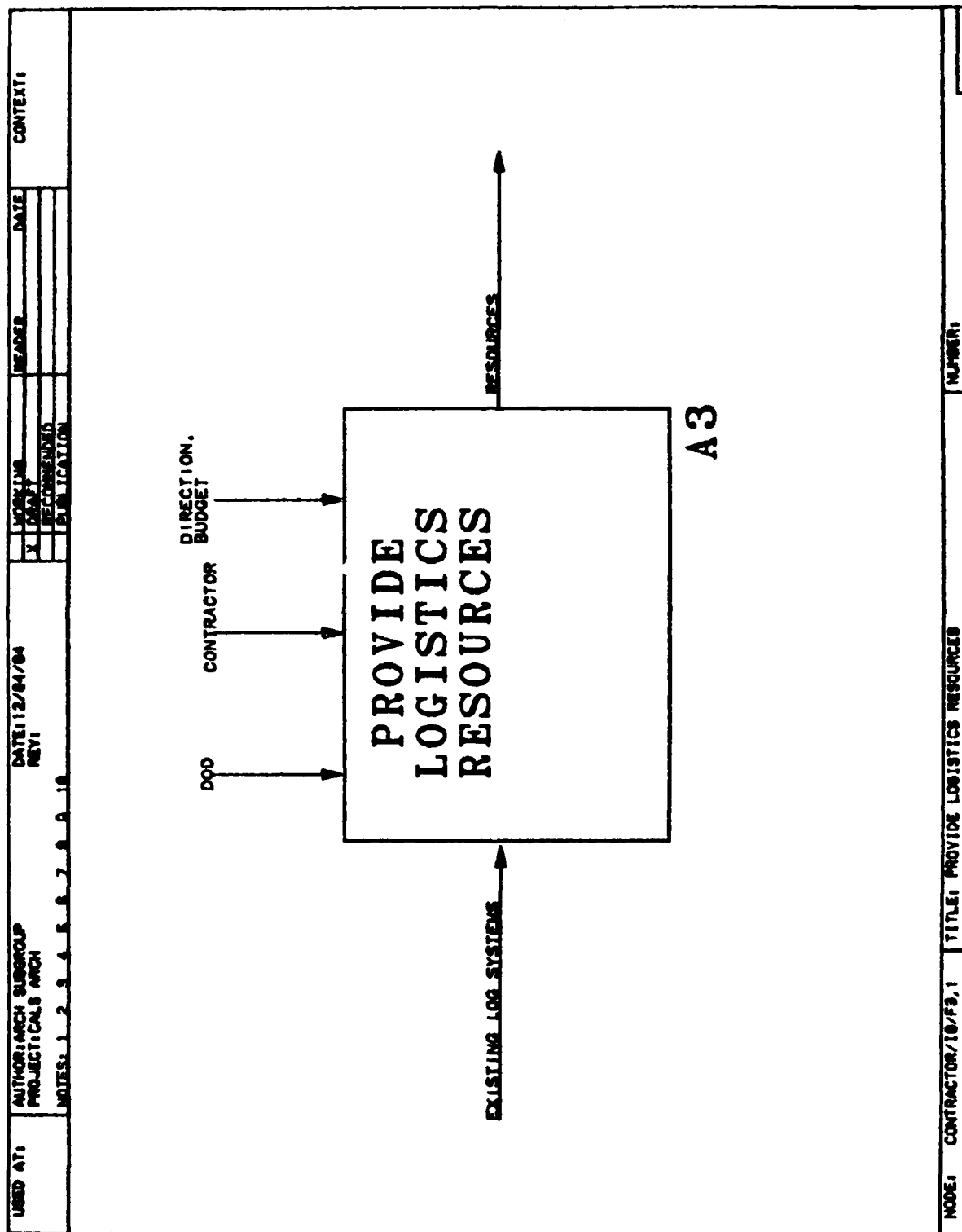


Figure 2-13. IDEF A3. PROVIDE LOGISTICS RESOURCES, CONTRACTOR

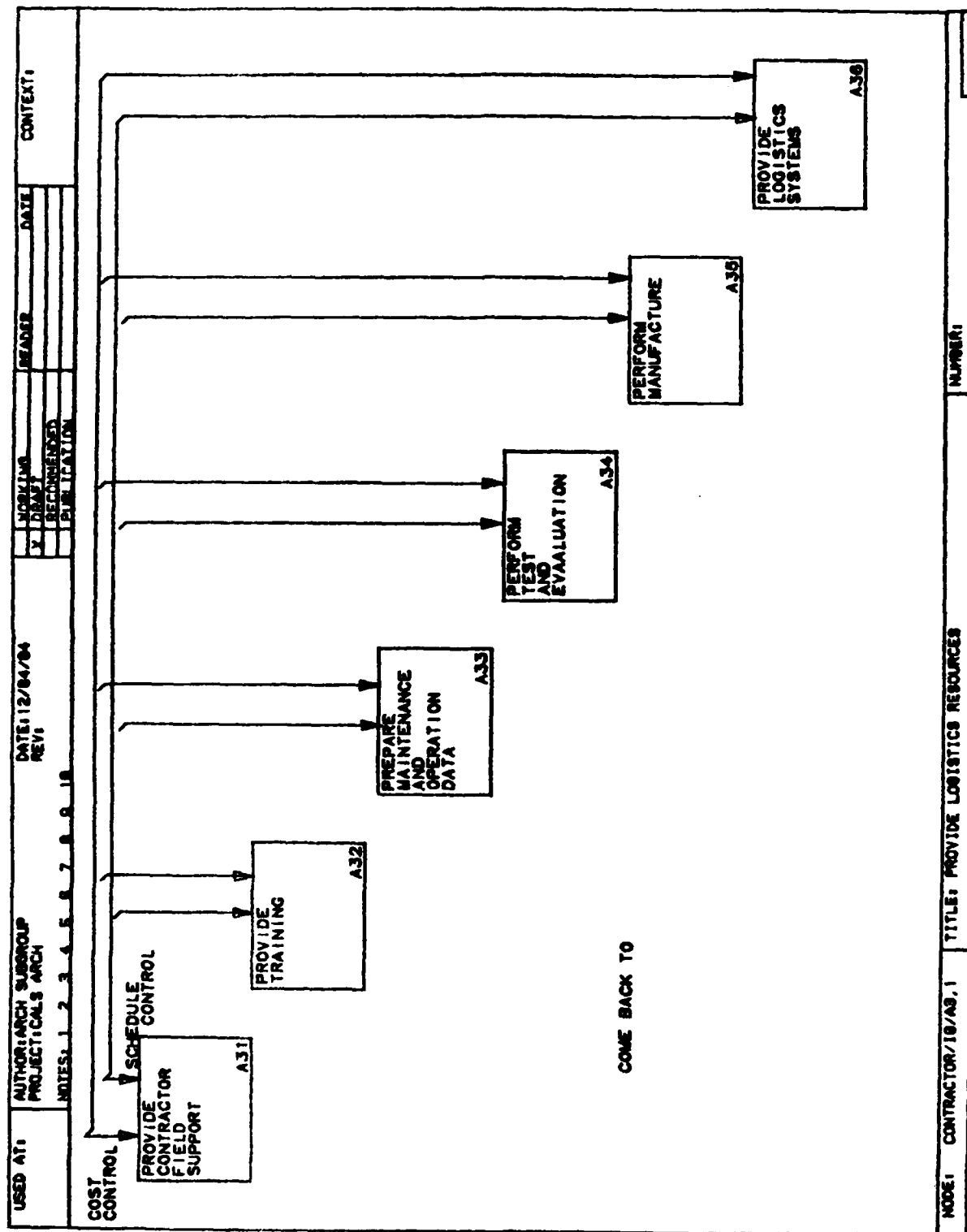


Figure 2-14. IDEF\_A3 n PROVIDE LOGISTICS RESOURCES, CONTRACTOR

CALS FUNCTIONAL DESCRIPTIONS  
CONTRACTOR FUNCTIONS:

8. IDEF A31, Contractor Field Support

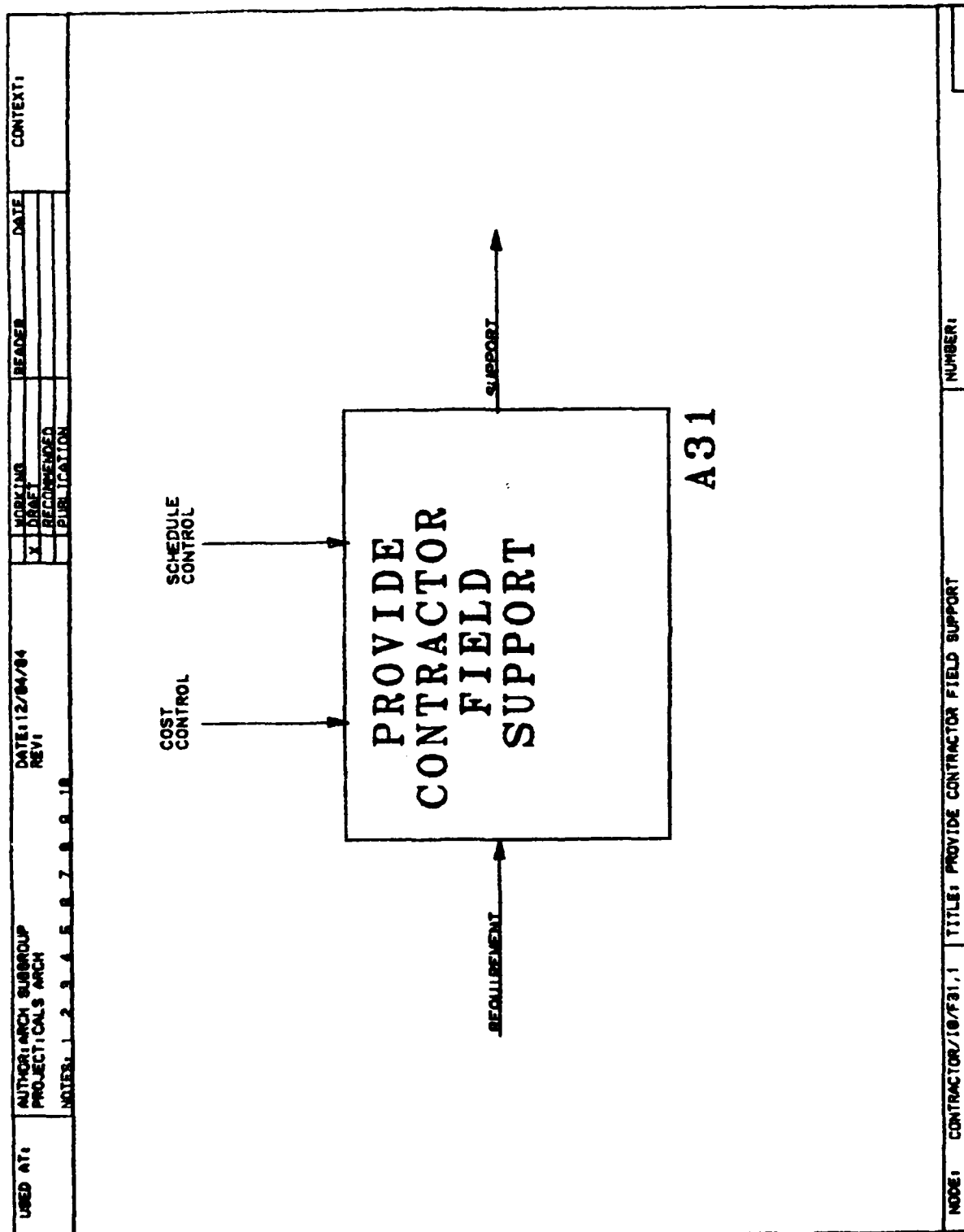


Figure 2-15. IDEF 31, PROVIDE CONTRACTOR FIELD SUPPORT



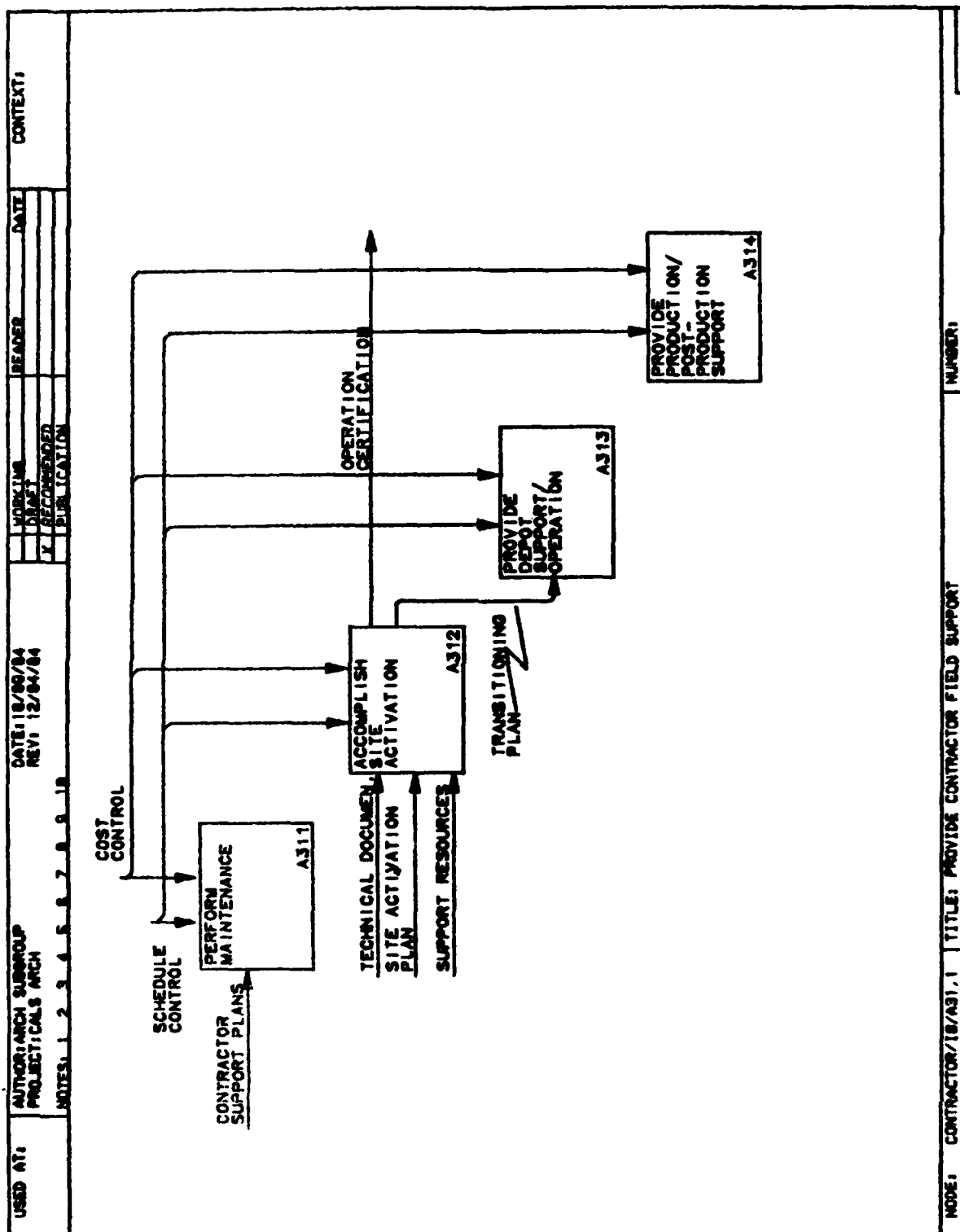


Figure 2-16. IDEF 31n, PROVIDE CONTRACTOR FIELD SUPPORT

IDEF A31 DESCRIPTION  
CONTRACTOR FIELD SUPPORT

- o CURRENT STATUS
  - Primarily hard copy
    - Inputs
    - Controls
  - Resource management primarily manual
- o TARGET SYSTEM CHARACTERISTICS
  - Automated (soft copy)
    - Inputs
    - Controls
  - Automated resource management
- o BENEFITS
  - Sites activated on schedule with complete support capability matching supported system configurations
  - Rapid response to keep support configurations current with system changes
- o PROBLEMS
  - Compatibility of contractor and Government data systems
  - Availability and compatibility of contractor data
  - Proliferation of high capacity PCs promotes creation and utilization of individualized unique systems exacerbating the centralized control and coordination problem
- o IMPLEMENTATION APPROACH
  - Standardize specifications imposed by Services on contractors for automation of deliverable technical data

- Services establish own automation capabilities to utilize and mesh with contractors automation systems
- Establish DoD oversight of Service activities in this area and provide specific DoD direction
- Provide adequate funding

o IMPLEMENTATION COST

- The approach is too MACRO at this point for any kind of useful cost estimate

**CALS FUNCTIONAL DESCRIPTIONS**  
**CONTRACTOR FUNCTIONS:**

**9. IDEF A32, Provide Training**



## A32 Provide Training

The basic data that will be used to develop the training programs will come from the engineer's design data base. However, training experts will have more and earlier input into the design process, requiring equipment to be designed with both embedded and external training as part of the design criteria.

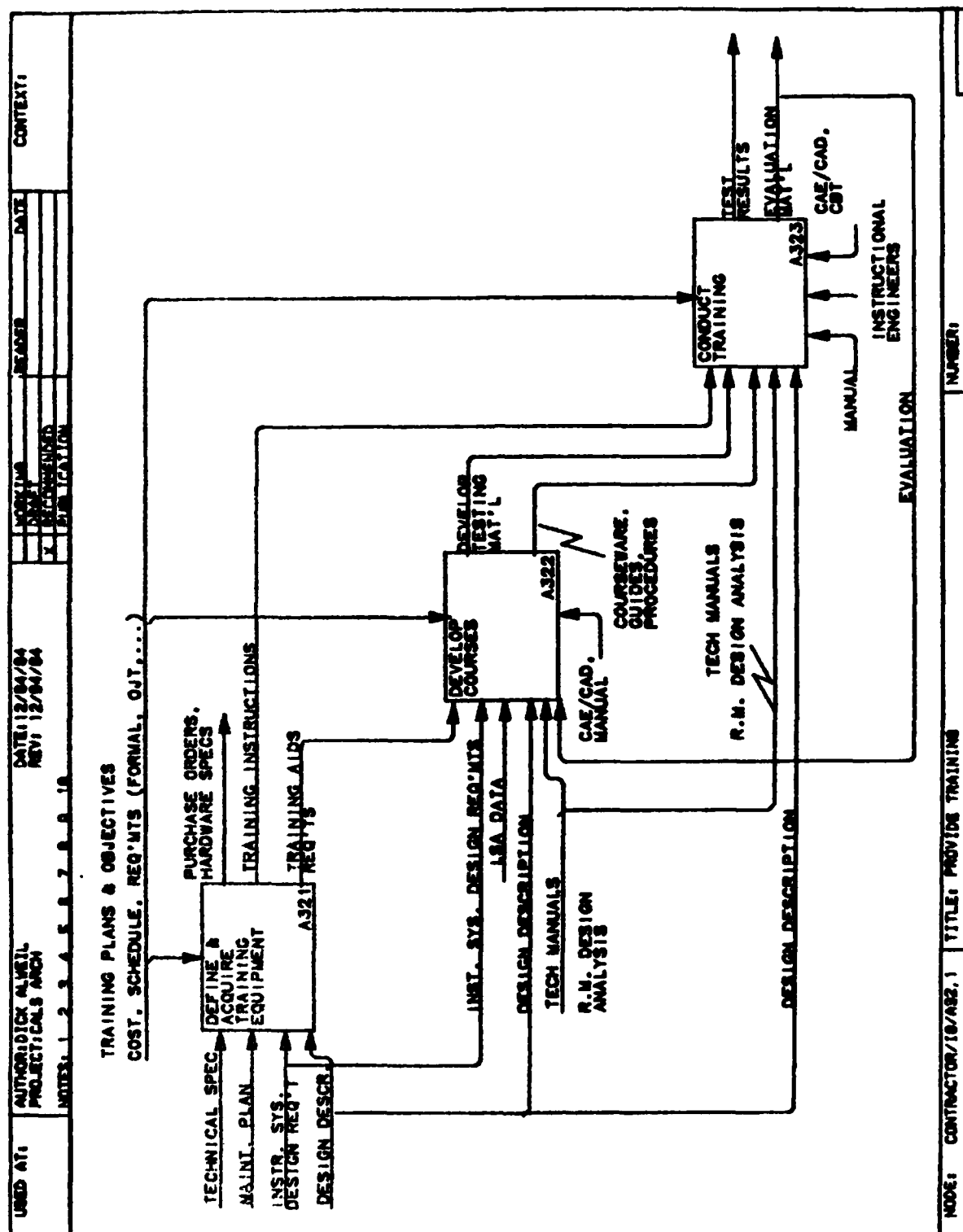
LSA data, an offshoot of the design data base, will also be computer-generated. This addition to the data base will then be used for the development of the maintenance task analyses which, in turn, leads to the training courseware. It forms the heart of the planning of the training programs and will be part of the total data base.

Manuals, documentation, and other forms of job aids will also be nonpaper-based in the future. Job aids will be stored digitally in the system or in specially designed ATE, and can be outputted as video, audio, text and/or a combination thereof. Such job aids will be available either by user demand or system initiation.

Equipment repair will be taught by modeling the steps and actions which have to be taken by the repairer. In the electronic manuals of the future, this may take place by having the system "dump" video and instructional logic into the repairman's portable integrated videocomputer. The interface for such a device must include options which allow for hands-free operation of the training device (e.g., speech input/output) by the repairman.

Systems operations training will, to a great extent, be resident on the system. Initial training will be the exception to this, but even initial training will be affected (i.e., reduced training requirements) by embedding operations training in the system.

New forms of training data will be developed to use the data base generated in design. However, they will be formatted to be suitable for interactive instructional purposes. A new skill, combining the technologies of engineering, training, and authoring, will be developed to put a suitable instructional program together. Authoring software will also be necessary to convert the training methodology into electronic form suitable for interaction.



### A32n Provide Training

Three activities are used to describe the framework for training. The first activity is the definition and acquisition of training equipment. Training equipment is presently defined by individuals knowledgeable in the methodologies of training for the system in question, and in the results required. They would develop a plan, determining hardware, software, and procedures; issue purchase requisitions, specification and design requirements; and make the appropriate arrangements to acquire all training materials.

The next activity is the development of courses. A System's training course is now planned and written after the design is completed, and usually after the hardware is built. Actual hardware is used to help design the course by running it through its paces and introducing faults and simulated situations. Courses are now developed for either computer-based training, human interaction, or simulation techniques using actual hardware.

The last activity is the actual conducting of training. Computer-based instruction, equipment simulation, and classroom and field training on actual equipment are all presently used.

Innovations which will affect training will occur in computer, video and training technologies. Computer-related advancements which will impact training include: improved user interfaces, cheap memory, multi-tasking machines, powerful handhelds, and reasonably costed 3-D color graphics systems.

Training technologies will advance to take advantage of delivery media improvements. Artificial intelligence (AI) concepts will be directly or indirectly applied to training. That is, where feasible, we will use expert training systems to provide instruction and assistance to operators and maintenance personnel.

### Glossary

**Cost, Schedule, Requirements** - Cost and Schedule restrictions are provided by the contract Statement of Work. On-the-job (OJT) training for persons not familiar with the equipment could allow performance of a task by using built-in computer aids. Defined by the contract Statement of Work as to the type of training required on the program. It could be formal, classroom training, on-the-job (OJT) training, or other types.

**Technical Specification** - That document provided as part of the contract which defines the operational, design and performance requirements of the system.

**Maintenance Plan** - Equipment Specification and/or Maintenance Scenario Analyses at a higher level.

**Instructional System Design Reqs** - Maintenance training, operator training, and general basic training as defined by design requirements.



A32n Glossary (Con't)

**Design Description** - Results of the design program; including drawings, analysis, schematics, test results.

**Order** - The process and data used to order material and services.

**Training Material** - Data used to conduct the training, other than the courseware (description of trainers, mock-up, etc).

**Training Aids Requirements** - The use of the training devices and how to integrate them into the overall training program.

**LSA data** - Logistics Support Analysis data.

**Technical Manuals** - As provided by Reliability and Maintainability design analysis.

**Testing Material** - The material used to evaluate the student's performance and the extent of learning; also the material used to evaluate the course content and presentation.

**Courseware, Guides, Procedures** - The training program and instructions on the methods to conduct the training.

**Training Plans and Objectives** - The achievement of built-in-training which provides for on-site field training for equipment use and maintenance.

**Test Results** - The results of testing the student in the course material.

**Evaluation Material** - The results of the students evaluations of the course, including recommendations for changes and improvement.

**Table 2-13**  
**DATA CONNECTIVITY INDEX FOR CONTRACTOR TRAINING IDEF CHART**

<u>Data Item</u>	<u>From or To</u>
<u>Information Input</u>	
Technical Specification	Contract and Statement of Work
Maintenance Plan	Preparation of Maintenance Data
Instructional system	Contract and Logistics Analysis
Design Requirement	
Design Description	Contractor Specification and Engineering data
LSA Data	Logistics Support Analysis
Technical Manuals	Publications Data
Rel and Maint Analysis	Logistics Design Data
Design Analysis	Engineering Data
<u>Information Output</u>	
Purchase Orders	Purchasing activity
Training Hardware	Purchasing activity and/or Design Engineering
Specifications	
Evaluation Material	Logistics Management
Test Results	Logistics Management
<u>Controls</u>	
Cost	Contract and Logistics Management
Schedule	Contract and Logistics Management
Training Requirements	Contract and Logistics Management
Training Plans and Objectives	Logistics Management
<u>Mechanisms</u>	
CAE/CAD	Engineering techniques
Computer-based training	Contractor-owned or Government furnished techniques
Manual	Contractor techniques
Personnel	Contractor techniques

IDEF A32, DESCRIPTION  
CALS INTERACTION WITH TRAINING

1. TRAINING EQUIPMENT DEFINITION AND ACQUISITION

a. Current Status: Training equipment is presently defined by individuals knowledgeable in the methodologies of training for the system in question, and in the results required. They would develop a plan, determining hardware, software, and procedures; issue purchase requisitions, specification and design requirements; and make the appropriate arrangements to acquire all training materials.

b. Target System Characteristics: In the future, the amount of built in training will be increased so the training expert will be defining the training methodology early in the design program. His input will be part of the design process, not after the fact. He will be using the CAE to understand and define the training aids and courseware needed to support the training process. A portion of his requirements will be acted upon by the design engineer and designed and built into the system.

All orders will be processed electronically.

c. Benefits: Better training programs will result due to an earlier integration with design. Built in training will increase the initial cost of the hardware but will reduce later training costs, maintenance and repair costs, and development time.

The CAE data base of the system will also be a source for designing the training hardware and software and will ensure full compatibility of the training program and its related equipment with the system design, even as changes occur.

d. Problems and Issues: New skills will have to be developed to create a new Instructional Engineer, combining the technologies of engineering, training and authoring.

Additional memory and storage capabilities must be built into each system to accommodate the built-in-training.

Design engineers and managers must be educated into the process and need for this new type of training.

Additional design and test time may be required.

Additional up-front costs may be required because of the need to integrate training with design, an earlier planning of the training program, and the potential increased costs of memory.

## 2. COURSE DEVELOPMENT

a. Current Status: A system's training course is now planned and written after the design is completed, and usually after the hardware is built. Actual hardware is used to help design the course by running it through its paces and introducing faults and simulated situations. Courses are now developed for either computer-based training, human interaction, or simulation techniques using actual hardware.

b. Target System Characteristics: Computer-generated design during the design process will enable the Instructional Engineer to simulate faults and situations without the necessity, in many cases, to use actual hardware. The courseware developed could, where desirable, be integrated into the design using the data and analysis developed by the Maintainability and Reliability Engineers. In this way, the work done by the Instructional Engineer in developing the courseware will not duplicate the R&M efforts but, in fact, will integrate their work into an overall training program. The courseware would also be evaluated using CAE technology. Naturally, all written material will be on computer or word processor.

c. Benefits: Early integration with design will improve both design and instructional material, ensuring course development from a common data base.

d. Problems and Issues: New skills will have to be developed to create a new Instructional Engineer, combining the technologies of engineering, training and authoring.

Additional memory and storage capabilities must be built into each system to accommodate the built-in-training.

Design engineers and managers must be educated into the process and need for this new type of training.

Additional design and test time may be required.

Additional up-front costs may be required because of the need to integrate training with design, an earlier planning of the training program, and the potential increased costs of memory.

### 3. CONDUCT TRAINING

a. Current Status: Computer-based instruction, equipment simulation, and classroom and field training on actual equipment are all presently used.

b. Target System Characteristics: All of the present techniques described above will be used. However, more of the data used will come from the digitized data and common data base of the design program. In addition, built-in-training will provide the capability for on-site field training for equipment use and maintenance. More simulation of equipment operation and failures will be done through the digitized data base and the built-in training. All of the manuals, design analysis, and other training aids will be available to the student in digitized format to aid in his training.

c. Benefits: More self-teaching aids will be available.

Training courses will be updated as quickly as the design is changed, and therefore kept current.

Training costs will be less.

More field and on-the-spot training will be available to more people.

Training will more easily be focused to a particular area and to a particular educational level when desired.

d. Problems and Issues: The technology which provides for software being built into each piece of equipment has to be developed and understood so as to provide for easy authoring, as well as appropriate training.

Small, portable interface terminals need to be developed and be made readily available at low cost.

Training technology has to advance so as to take advantage of computer-based information and instruction.

Studies have to be made into new methods of training suitable for these techniques.

**IDEF A32 CONCEPT PAPER**  
**CALS INTERACTION WITH TRAINING**

**1. FOCUS AND IMPLEMENTATION CONSIDERATIONS**

**1.1 Overview:** As the amount of electronic digitized data in the design and development of systems becomes greater and greater, questions arise as to how to best use the data for training purposes. This leads us to consider:

- a. What should training be like in the near future in terms of methods, functions, and performance?
- b. What data from the design data base would be appropriate for use?
- c. What new data would have to be generated?
- d. What format should the data and the training activities take?

The training that will be considered encompasses three basic areas: maintenance training; operator training; and general basic training.

The major technological innovations on the horizon will affect the way training is designed, developed, delivered and managed.

Innovations which will affect training will occur in computer, video and training technologies. Computer-related advancements which will impact training include: improved user interfaces, inexpensive memory, multi-tasking machines, powerful handhelds, and reasonably costed 3- $\Gamma$  color graphics systems. Videodisc improvements will continue to happen coincidentally with improvements in digital information storage. The physical size of discs will probably shrink while frame counts increase; sound over stills will become practical as will read/write and easily reprogrammable discs; and integrated portable videocomputer devices will become available.

## 1.2 Projected Performance of the Target Computerized Functions.

Training technologies will advance to take advantage of delivery media improvements. Artificial intelligence (AI) concepts will be directly or indirectly applied to training, where feasible. Expert training systems will be used to provide instruction and assistance to operators and maintenance personnel. Even before training technology advances to the point where AI is practical, the ideas and concepts of AI can be incorporated into the training environment. Definitions of what constitutes training will also expand as systems are produced with embedded training. Training aids incorporated as part of the product, and automated job aids, will be major elements in the training media mix of the future.

The basic data that will be used to develop the training programs will come from the engineer's design data base. However, training experts will have more and earlier inputs into the design process, requiring equipment to be designed with both imbedded and external training as part of the design criteria.

Complex systems will require either more sophisticated operators and maintainers, or will be designed to support lower aptitude personnel. Training implications of design alternatives will be a major consideration when specifying subsystem characteristics. The systems will probably incorporate computer technology as part of each major subsystem. Part of the data stored at the subsystem level will be usable in a training mode. The "training" data may be part of the built-in test equipment (BITE) and/or automatic test equipment (ATE) on the system, or they may be accessible by the user when training is needed. BITE and ATE components will have their functionality increased so that more analysis and diagnosis of faults and recommended corrective procedures will be done internally by the systems. For example, systems will be able to check their own boards and "tell" the maintainers to replace a specific faulty chip on a particular



board. Also, if an operator sets a dial to a nonstandard position, the system will be "smart" enough to ask the operator if that is indeed the desired setting. When the setting has dangerous effects, it will not allow the setting. The communications link between the system and the maintainer or operator will be a form of training on future systems.

Systems of the future will be designed and defined on CAE/CAD/CAM systems. The computer will have a 3-D description of the system in its data base. A 3-D graphics-based training system will access the CAE/CAD/CAM data base to create a training simulator of the real system. In the simulated system, accurate to the level of detail in the CAD/CAM data base, the trainee can safely learn and experiment with a representation of the system. The open endedness of the simulation is based on the capabilities of 3-D graphics systems to do real-time motion with infinite perspectives of the equipment, and implementable AI knowledge representations which reflect how the equipment works.

A video image of the equipment can be presented from the design data base. Assembly and disassembly can be simulated and interactively operated by the student. Both electronic and mechanical performance can be simulated under various conditions to instruct the student as to how the equipment works. Faults can also be introduced and repair procedures stepped through. This will all be guided by an interactive audio-video presentation designed and structured to teach the student to operate and/or maintain the system or equipment.

LSA data, an offshoot of the design data base, will also be computer-generated. This addition to the data base will then be used for the development of the maintenance task analyses which, in turn, leads to the training courseware. It forms the heart of the planning of the training programs and will be part of the total data base.

Manuals, documentation, and other forms of job aids will also be nonpaper-based in the future. Job aids will be sorted digitally in the system or in specially designed ATE, and can be outputted as video, audio, text, and/or a combination thereof. Such job aids will be available either by user demand or system initiation.

These job aids actually perform on-the-job training for persons not familiar with the equipment. Depending upon complexity, this could allow persons not specifically trained in a particular equipment maintenance task to perform that task by using the built-in computer aids.

Equipment repair will be taught by modeling the steps and actions which have to be taken by the repairer. In the electronic manuals of the future, this may take place by having the system "dump" video and instructional logic into the repairman's portable integrated videocomputer. The interface for such a device must include options which allow for hands-free operation of the training device (e.g., speech input/output) and the repairman. Systems operations training will, to a great extent, be resident on the system. Initial training will be the exception to this, but even initial training will be affected (i.e., reduced training requirements) by embedding operations training in the system.

A major area where embedded training will only be an adjunct is the operation of complex systems which require psychomotor skills which must be practiced in a simulator for safety and practical considerations (e.g., weapon systems). Embedded training will require that multi-tasking concepts be part of each subsystem so that the operator can access training/job-aid materials while in the process of operating the equipment. The training materials will be directly relevant to the operational tasks being performed.

New forms of training data will be developed to use the data base generated in design. However, they will be formatted to be

suitable for interactive instructional purposes. A new skill, combining the technologies of engineering, training, and authoring, will be developed to put a suitable instructional program together. Authoring software will also be necessary to convert the training methodology into electronic form suitable for interaction.

**1.3 Implementation Considerations.** No amount of computer-based instruction, electronic simulation, or the like, will ever replace the need to have some real-time human interaction with an instructor during a major training program. The human will work in conjunction with computer-aided training, but as the systems becomes larger and more complex, human interaction will remain a requirement.

In addition to the basic design data that will be provided for training, the student will also have access to other data to increase the level of his performance. Such items as IPBs, RPSTLs, reliability predictions, and results of other analysis will be available for his use so as to make his understanding of equipment performance and maintainability even greater. Major innovations in training-related technologies will cause changes in the way training is delivered in the future. The major change, however, is not in the mechanics of training implementation, but rather in an extension of the definition of what constitutes training. We can be reasonably sure of the advances in hardware and software technologies because of the large amount of research and development being conducted in both the Government and private sectors. Similar significant advances will have to be made in the training domain. Training-related research and development is required for improvements and breakthroughs analogous to those in other technologies. In order for the training community to be ready to apply tomorrow's technological advances effectively, investigation and further development of training theory, methodologies, techniques, and approaches must be undertaken today.

**1.4 Likely Payoffs and Benefits.** There are many benefits envisioned when the training methodology utilizes the computer-based digitized data and when it is integrated into the design of equipment.

- a. Better training programs will result due to an earlier integration of the training equipment and its requirements with system design.
- b. Built-in training may increase the initial cost of the hardware, but should reduce later training costs, maintenance and repair costs, and development time.
- c. Early integration with design will improve both design and instructional material, ensuring course development from a common design data base.
- d. More self-teaching aids will be available, and will be interactive with the student.
- e. Training courses can be updated as quickly as the design is changed, and therefore kept current.
- f. More field and on-the-spot training will be available to more people. Human interaction can be kept to a minimum where not required.
- g. Training can more easily be focused in a particular area and to a particular educational level when desired.

**1.5 Anticipated Problems and Changes Needed.** Developing integrated training by using the computer-based digitized data will not be easy. As a matter of fact, it is close to being a revolution in training technology; very little of it exists today. Some of these changes that are required are as follows:

- a. New skills will have to be developed to create a new species of Instructional Engineer, combining the technologies of engineering, training and authoring.
- b. Additional memory and storage capabilities must be built into each system to accommodate the built-in-training; therefore, low cost memory is a must.
- c. Design engineers and managers must be educated into the process and need for this new type of training.
- d. Additional design and test time may be required.

- e. Additional up-front costs may be required because of the need to integrate training with design, earlier planning of the training program, and the potential increased costs memory.
- f. The technology which provides for software being built into each piece of equipment has to be developed and understood so as to provide for easy authoring, as well as appropriate training.
- g. Small, portable interface terminals need to be developed and be made readily available at low cost.
- h. Training technology has to advance so as to take advantage of computer-based information and instruction.
- i. Studies have to be conducted for new methods of training suitable for these techniques.
- j. Development schedules will be longer to accommodate the design, development and test of the training function.

## 2. IDENTIFICATION OF CANDIDATE FUNCTIONS

The whole concept of the future of training technology is how it is tied to, and integrated with, the design process. The use of the common design data base early in the design process, and influencing the design because of training requirements, is crucial in the development of training in the digitized world. A type of system that would most likely take early advantage of this new training methodology would be an electro-mechanical system that will be used by any of the Services.

## 3. ANTICIPATED RECOMMENDATIONS

3.1 Funding Issues. Because integrated training is required early in the design program, more up-front money will be required in procuring such a system. The cost of a system may also be increased due to the additional software and hardware required to make these new training concepts operational. However, the life cycle costs and future training costs will decrease. A trade-off will be required to justify the early expenditures as a means of reducing follow-on costs.

**3.2 Incentive Issues.** Government's incentives are to increase system readiness, improve deployability/sustainability, better utilize manpower and to reduce long-term costs. All of these are possible with computer-integrated training. These incentives must be passed along to the Contractor.

In addition, development of these new training technologies will never happen unless the Government provides funds for research and development.

**3.3 Contractual Issues.** The major contractual issues that need to be addressed include the methods for specifying, testing, and accepting integrated training. The RFP should specify the need and define a method by which training will be imbedded, integrated with the design process, and used in the field.

**3.4 Specifications and Standards Issues.** New standards and specifications would be required for this new technological approach. These documents must be coordinated by all Services and must be defined so as to have appropriate interfaces with all the necessary peripherals. At the same time, standard interfaces with hardware and software peripherals need to be defined.

These standards must be developed early on, otherwise chaos will result with the training equipment (i.e., portable terminal) not being able to interface with the system for which training is required.

**3.5 Technological Changes.** The technological changes required have been discussed in paragraph 1. The most important include:

- Development of the new training technology
- Computer-related advancements
- Improvements in the video disc system

3.6 Policy Issues. There does not appear to be any significant Government policy issues that stand in the way of integrating training with the design process and its utilization of computer-aided technology.

#### 4. JUSTIFICATION FOR THE CHOICE OF THE CANDIDATE

A small electro-mechanical system should be chosen because of the capability to develop and build-in the training programs early in its design phase. It would be a system that is fairly easy to manage, and one where the developing technology parallels the system technology.

For a first-time project, it would probably be more easily specified, tested, and evaluated than, say, a large weapons system. Yet, it would have all the training elements involved.

Most design efforts in developing an electro-mechanical system are computerized now, so the use of the digitized data would not be foreign to the contractor.

Finally, the evaluation of the benefits could be made more easily and more quickly than many other potential choices because of the relatively high visibility of all cost elements and the reasonably short turnaround cycle.

**CALS FUNCTIONAL DESCRIPTIONS**

**CONTRACTOR FUNCTIONS:**

10. IDEF A33, CALS for the Preparation of Maintenance and Operation Data



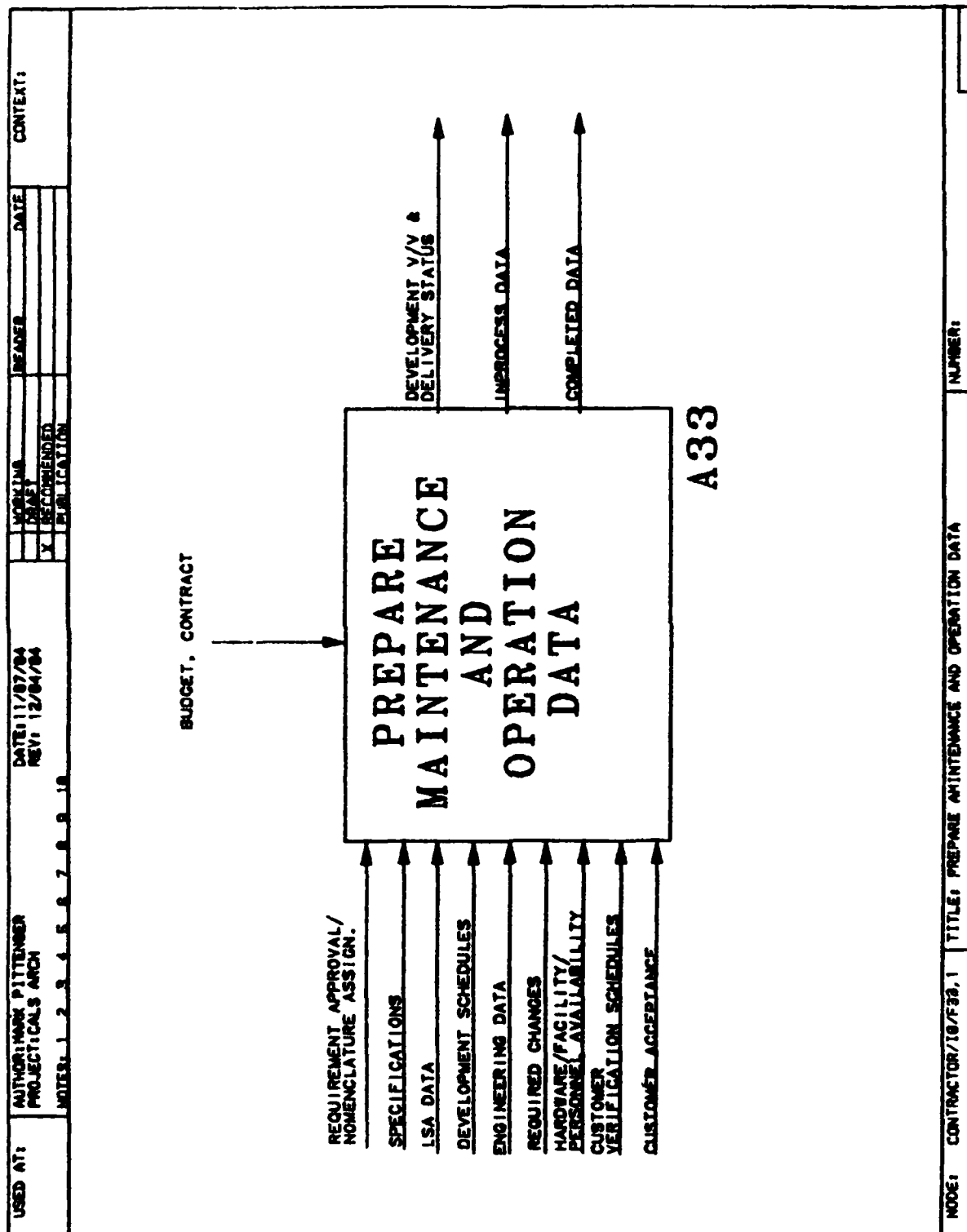


Figure 2-19. IDEF A33, PREPARE MAINTENANCE AND OPERATION DATA, CONTRACTOR

### A33 Prepare Maintenance and Operation Data

Industry incentives will be provided by the continuing pressure to improve productivity and reduce costs. Development of a standard data interchange format will assist in directing industry investment toward a systems that can communicate with those of the services.

Near term funding will be required in order to take advantage of current industry investment plans, maximize return on investments being made in service systems and to lay the foundation for longer-term advances. Funding these activities will require that they be given a high priority within DOD. The fact that the majority of savings to be had in this area is in the form of cost avoidance rather than cost savings will not make its funding any easier.

Prioritization of funding should be as follows: first, development of near-term data exchange formats, second, development and implementation of service systems to receive, distribute, archive and update computerized publication data, and third, development and demonstration of data authoring capabilities for interactive maintenance aids.

Computerization of the technical publication process offers high payoff opportunities in a number of areas. The most significant of these is simply the opportunity to continue operations in a reasonable manner. The process of developing, distributing and maintaining paper based technical publications has become so unwieldy that its continued viability is in doubt. The existing structures have been stretched nearly to the breaking point by increased page counts, higher costs, longer flow times, increased number of publications and funding realities.

Significant cost payoffs include, 1) Reduced (or contained) data acquisition costs through continued industry automation, 2) Lower future change costs through availability of high quality electronic source data and 3) Improved weapon support through timely data update, faster distribution, and reduction (or elimination) of change page insertion.

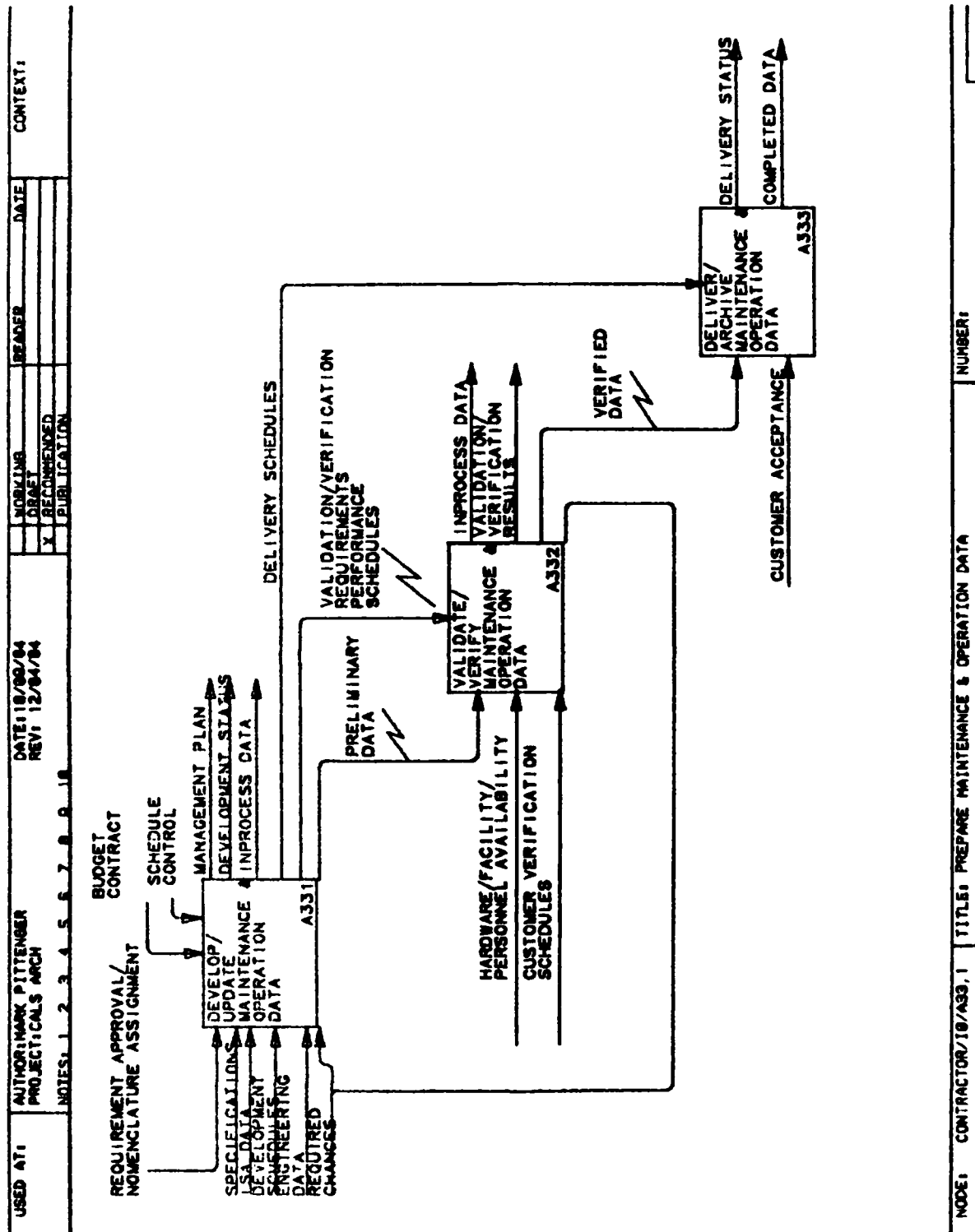


Figure 2-20. IDEF A33n, PREPARE MAINTENANCE AND OPERATION DATA

### A33n Prepare Maintenance and Operation Data

There are three activities which describe the preparation of maintenance and operation data. The development/updating of maintenance and operation data is subject to automation procedures such as: automated production, computer-aided authoring, and de-centralized production.

Validation/Verification of maintenance and operation data is the second activity. The current quality assurance functions for plate negative deliverables are accomplished through examination of the completed product for compliance with specification requirements. Verification that electronic data deliverables comply with requirements will mandate development of new, automated methods for performing quality assurance checks.

The delivery/archival of maintenance and operation data is the third activity. The emerging industry standards for a digital deliverable are the GENCODE and IGES standards. This standardization, however, is occurring as a result of the need to transfer graphics from CAD to publication systems and to produce data on a variety of devices (laser printer, typesetter, etc.) without reformatting it.

### Glossary

Requirement Approval - Approved maintenance requirements and planning - from LSA function.

Nomenclature Assignment - Assignment of official Government nomenclature to an item.

Specifications - Development of suitable data delivery formats and standardization of those formats throughout the services.

LSA Data - Logistics Support Analysis data.

Development Schedules - Under the restrictions imposed by the Contract Statement of Work.

Engineering Data - Aperture cards of assembly drawings, schematic wiring diagrams, wire lists, etc.

Required Changes - Changes required by virtue of design changes or correction of errors.

Budget/Contract - Constraints due to financing or contractual requirements.

Management Plan - Work plan to accomplish requirements.

Development Status - Record of design progress.

Inprocess Data - Under the restrictions imposed by the Contract Statement of Work.

Delivery Schedules - As specified by the contract.

A33n Glossary (Con't)

Validation/Verification Requirements - Delineation of what is required of the contractor and Government to prove the accuracy and contractual compliance of the material.

Preliminary Data - Maintenance and operation data which has not been verified or validated.

Hardware/Facility/Personel Availability - Schedule of resource availability for maintenance.

Customer Verification Schedules - As specified by the contract.

Validation/Verification Results - Outputs from review of the analyses and/or demonstrations.

Verified Data - Maintenance and operation data which has been reviewed and validated.

Customer Acceptance - Approval of an item to enable closure and payment.

Delivery Status - Status against specified delivery dates.

Completed Data - Data that has been completed and accepted.

## IDEF A33, DESCRIPTION

### CALS FOR THE PREPARATION OF MAINTENANCE AND OPERATION DATA

#### Current Status:

- o Manual Authoring
- o Semi-Automated Production
- o Plate Negative Deliverable
- o Centralized Production
- o Hard Copy Distribution
- o Paper Delivery of Data to Users

#### Target System Characteristics:

##### Short Range

- o Computer-Aided Authoring
- o Automated Production
- o Electronic Deliverable Format
- o Electronic Distribution
- o De-Centralized Production
- o Paper Delivery of Data to Users

##### Long Range

- o Computer-Aided Authoring
- o Automated Production
- o Highly Structured Electronic Delivery Format
- o Electronic Distribution
- o On-Demand Interactive Delivery
- o Configuration and Skill Sensitive

#### Benefits:

##### Short Range

- o Reduced or Contained Data Preparation/Update Costs
- o Shorter Update Flow Times
- o Shorter Distribution Flow Times
- o Reduced Field Publication Maintenance Effort
- o Potential for Improved Fault Isolation Procedures

##### Long Range

- o Improved Fault Isolation Capabilities
- o Integrated Maintenance and Training Data
- o Skill Level and Configuration Sensitive Presentation

#### Problems:

- o Absence of Electronic Delivery Formats
- o Front End Funding for Standards Development
- o Front End Funding for Development of Service Systems
- o Printing and Distribution Bureaucracy
- o Service Prioritization

- o Deliverable Product Standardization
- o Integration of Service Efforts
- o Potential of Higher Long Term Data Preparation Costs
- o Confusion Concerning Appropriate Service and Industry Roles

**Implementation Approach:**

- o Integrated Efforts of Services
- o Develop and Implement Computer Sensible Deliverables
- o Implement Service Archive, Update and Distribution Systems
- o Continue Interactive Maintenance Aid Efforts of Services

**Implementation Cost:**

- o Detailed Estimate Not Available
- o Will be Higher if Effort is Not Initiated in Near Future

## IDEF A33 CONCEPT PAPER

### CALS FOR THE PREPARATION OF MAINTENANCE AND OPERATION DATA

#### 1. FOCUS OF CALS IMPLEMENTATION

**1.1 Projected Performance of the Target Computerized Functions.** Industry efforts associated with preparation of weapon system operation and maintenance data are currently directed toward delivery of plate negatives for the printing of paper-based technical publications. Increasing labor and material costs, coupled with competitive considerations, have resulted in modernization and automation of the publication production process by industry. The technology utilized in the production process has progressed from typewriters, inked illustrations and photographic reproduction to wordprocessing, interactive computer graphics and photo-typesetting. At the same time that the technology of publication production has been advancing, commensurate improvements have been made to their usability. In response to the increasing complexity of weapon systems, declining technician experience, lower skill levels and limited training opportunities, manuals have evolved from minimally illustrated procedural documents to today's highly illustrated, human engineered, "job guide", "new look" and "skill performance aid" manuals.

While automation of the production process has tended to lower the cost of technical publication preparation, higher labor costs and an increased volume of data have tended to increase them. The net result of these trends has been a decrease in the number of hours required for preparation of a manual page and an increase in its dollar cost. This higher page cost, coupled with the increased number of pages required for modern weapon systems, has substantially increased the total cost of acquiring technical publications.



DoD components have experienced difficulties similar to those of industry as the costs of maintaining and distributing publications have risen along with page counts and the number of publications that must be supported. Unlike industry, however, little has been done to modernize and automate the DoD technical publication distribution and maintenance process. Indeed, the very nature of the deliverable product (plate negatives that are not computer sensible) has, to a large degree, precluded DoD implementation of many of the advancements industry has made. As a result, the flow time for delivery of manuals frequently exceeds six months, and backlogs of manual changes are such that updates are often restricted to mandatory safety and "make-work" items. In addition to the cost impact, these difficulties have a corresponding detrimental impact on weapon system readiness.

DoD weapon system users also have experienced their share of difficulties with technical publications. The lengthy flow time associated with publication updates frequently results in maintenance personnel working with out-of-date, incomplete or incorrect data. Insertion of change pages alone is a significant consumer of weapon system maintenance man-hours. However, probably the most significant difficulty experienced by weapon system users is the limited usefulness of paper-based publications as diagnostic aids. Fault isolation procedures are generally developed early in the life cycle of a weapon system, when a minimum of experience has been gained concerning failure modes and maintenance difficulties. The lengthy update process and minimal feedback of historical maintenance data serve to further minimize their usefulness. Attempts have been made to improve the usefulness of technical publications as diagnostic aids, but have generally proven to be too expensive for widespread implementation. While of some assistance, improved publication formats have not completely compensated for reduced levels of maintenance manning, lower skill levels and increasing system complexity. In the final analysis, diagnosis

of weapon system faults depends primarily upon the quality of a weapon system's fault isolation features (BIT, BITE, ATE) and the experience of the maintenance technician.

In response to these difficulties, DoD has initiated a number of recent efforts. Among the more significant of these are the Air Force ATOS (Automated Technical Order System) and the Navy NTIPS (Naval Technical Information Presentation System) projects. The ATOS effort is directed at implementation of capabilities similar to those of industry for maintenance and update of technical publications and to serve as a basis for development of an electronic distribution system. The NTIPS effort is focused upon development of improved concepts for authoring and delivery of maintenance and operation data.

Significant improvements need to be made to both industry and DoD technical publication activities. The limitations of the plate negative deliverable and paper-based distribution system have been reached, both in terms of affordability and weapon system supportability.

In the near term, DoD must move from a system based upon paper pages to one based upon electronic equivalents of those pages. This is not to say that paper will be entirely eliminated. Rather, instead of being printed by an independent contractor and distributed from a central location, it will be produced at a de-centralized data center or on-demand at the work location. Implementation of this type of system would help alleviate many of the difficulties inherent in the present system, including high data preparation and update costs, lengthy update flow times and the need to manually insert revision pages. In addition, reduction of the update flow time and cost would also enable fault isolation procedures to be more useful through timely incorporation of field experience into the procedures. Such a system would include the elements of electronic authoring, a computer sensible deliverable product and a capability for DoD components to archive, maintain and distribute data electron-

ically. Needed data would be provided to the user in the near term through distributed data centers or by print-on-demand systems and possibly, in the longer term and at fixed locations, by display on a computer terminal.

Several DoD actions will be necessary to implement such a system. The first of these is to develop a computer sensible technical publication delivery format. Industry is currently making a significant investment in computer hardware and software for use in development and production of technical publications. This effort, however, is directed toward development of deliverable plate negatives rather than electronic data sets. In order to take advantage of these contractor developed digital data bases, DoD must provide a means for their delivery. Development and imposition of a digital deliverable would also provide an incentive for industry to continue its investment and move to fully computerized processes. DoD activities would benefit by obtaining the data in a form that would be usable for preparing manual updates and usable as source data for subsequent procurement activities. It also could be distributed by electronic means. The second required action is to implement DoD computing systems capable of supporting digital technical publication data archive, update and distribution activities. The near- and mid-term actions discussed above should be viewed as a means of transitioning from paper to computer based technical publications.

In the longer term, the technology needed to interactively present maintenance and operation data, assist with fault isolation and provide training data will soon be available. As maintenance aiding devices that utilize this technology are fielded, the technical publications function will evolve from one of preparing, maintaining and distributing paper technical manuals to one of preparing, maintaining and distributing electronic data for these devices. In addition, these data will be structured around the maintenance task rather than the book. Rather than presentation of a printed page as the usable element,

data will be constructed around definable tasks, such as "Landing Gear Removal", in order to take maximum advantage of the new medium. This will also require redefining training and maintenance requirements, along with their accompanying DoD organizations, to take advantage of the new delivery medium. Since the technology will allow delivery of maintenance and training data on the same device, there will be no visible division between maintenance and training data. Unlike the near- and mid-term actions that were discussed above, the benefits of making the transition to these interactive maintenance aids will come almost exclusively from operation and support cost savings by weapon system users. Indeed, even with increased use of Computer-Aided Design and Logistic Support Analysis data, it is possible that the costs of preparing data for these devices will be higher than those associated with preparation of conventional technical publications.

## **1.2 Implementation Considerations.**

**1.2.1 Technical Considerations.** The primary near-term technical consideration in modernizing the DoD technical publication process will be development of a suitable electronic delivery format. Within industry, the emerging "de facto" standards for a digital deliverable are the GENCODE (GENeric CODing) and IGES (Initial Graphics Exchange Standard) standards. This standardization, however, is occurring principally as a result of the need to transfer graphics data from CAD to publication systems and to produce data on a variety of devices (laser printer, typesetter, etc.) without reformatting. Their suitability for use as a deliverable format requires an in-depth examination. It is possible that, rather than a single format, several will be required in order to accommodate all of the various types of technical publications.

Other near-term technical issues that require consideration include appropriate equipment selection and configuration for

Service systems, validation of industry deliverable data formats and translators, and development of high resolution computer terminals capable of displaying conventional 8 1/2" x 11" page formats.

Longer term technical issues include the need to quickly transmit large volumes of graphics data, development of methods to author and present data using multiple colors, development of methods for compact physical and electronic storage data, integration of the various data sources (BIT/BITE, spares, CAD, LSAR, etc.) and development of new configuration control and quality control techniques. Of primary concern will be the need for extensive study of user interaction with non-paper maintenance aids. Data presentation techniques, the use of color, video presentation and audio delivery must be evaluated and an optimum mix of techniques selected to derive the most benefits from the new medium.

**1.2.2 Contractual Issues.** The primary near-term contractual issue that must be addressed is that of how quality assurance functions will be accomplished for electronic data. Quality assurance functions for plate negative deliverables are accomplished through examination of the completed product for compliance with specification requirements. Verification that electronic data deliverables comply with requirements will mandate development of new, automated, methods for performing quality assurance checks.

A secondary contractual consideration will be the appropriate means of funding expenditures for publication automation when they are contractually specified. There exists within industry a significant amount of opinion to the effect that such costs should be shared or matched by the specifying DoD component. Without such provisions, it will be difficult for small businesses and lower tier subcontractors to comply with requirements for delivery of digital publications data.

A longer term issue will be that of developing a new basis for pricing data development. Near-term activities will probably continue to utilize the number of manhours-per-page as the basis for pricing. When systems are fielded that present data on an interactive basis, pages as such will no longer exist. Some other basis, such as the maintenance task, will have to be developed for pricing and negotiating contracts.

**1.2.3 Integration Issues.** Near-term integration issues include: development of multi-service electronic delivery formats, integration of publication requirements with the LSAR and Provisioning Technical Documentation (PTD) and integration of publication requirements with CAD/CAM. In order to minimize the number of translating programs and interfaces that must be maintained by industry and DoD, it is important that the number of individual data delivery formats be minimized. Development of a minimum number of formats will require the cooperation of all DoD components and assignment of a DoD level office to coordinate and manage their development. A second issue is that of integrating publications activities into the LSAR process. Current LSAR standards provide little assistance to the publication identification and development process. The LSAR process needs to be enhanced to provide for discrete identification of publication requirements, to relate publications to particular maintenance tasks and to define the relationship between LSAR data, Provisioning Technical Documentation (PTD) and the various Illustrated Part Breakdown/Repair Part and Special Tool List publications. Integration of publications and CAD/CAM requirements could significantly reduce the amount of effort required to develop and update technical publications. Engineering data and publications data have many strong relationships, but are developed and procured under separate standards. Integration of the requirements contained in these standards would provide for development of engineering products that are directly usable in

technical publications. Schematic wiring diagrams and wire lists are two of the areas where significant savings could be made.

These near-term actions will form a basis for integration of the activities that will be associated with preparation and delivery of data for use by future interactive maintenance aids. Data will be both more complex and more highly structured than present technical manual data. In order to cost effectively develop and maintain this data it will be necessary to make maximum use of data that are developed as part of the design, manufacturing and support system development activities. Development and implementation of the means to integrate and utilize data from these various sources poses a significant integration challenge.

**1.3 Likely Payoffs and Benefits.** As discussed in paragraph 1.1, near-term benefits of automating the DoD publication process include:

a. Reduced or at least contained out-year data preparation and update costs as a result of continued automation of the authoring and production processes and the availability of high quality electronic source data.

b. Shorter flow times for incorporation and distribution of publication updates due to continued automation, distributed/print-on-demand data production and electronic distribution.

c. Reduced publication maintenance effort by weapon system users due to a reduction, and possible elimination, of the need to insert publication revision pages.

d. Improved fault isolation procedures as a result of improved feedback of field experience data and shorter update flow times.

Longer-term benefits will be almost totally in the operations and support area and will include:

a. Greatly improved fault isolation capabilities through the use of interactive troubleshooting aids.

b. Integration of training and maintenance data preparation activities through utilization of a common delivery medium.

c. Ability to present maintenance data at a level of complexity appropriate to the skill level of the maintenance technician.

Other, less tangible benefits will include improved data access, skill improvement through on-demand remedial training and development of maintenance generalists rather than specialists (this will support the various year 2000 concepts for remote site maintenance).

**1.4 Changes Needed and Problems.** The changes that need to be made to the DoD publications process are discussed in paragraph 1.1. Problems that will be encountered in implementing them include:

a. Benefits will accrue primarily to weapon system users, while implementation costs and difficulties will fall primarily upon weapon system developers and managers. In addition to the development effort and costs, implementation of the improved capabilities discussed in paragraph 1.1 will require that significant changes be made to present methods of procurement and support, and the organizations that perform them. None of these changes will provide any large incentive for their implementation.

b. Obstacles posed by the extensive bureaucracy associated with printing and distribution of paper-based publications must be considered. Printing and distribution activities for paper based technical publications employ a large number of people in the government sector and are a major source of income for independent printing contractors. No attempt to eliminate traditional printing of publications will be greeted with enthusiasm by either of these parties.



c. Development and implementation of authoring capabilities for interactive maintenance aids are going to require a significant investment on the part of both industry and the Services. It is probable that, at least initially, costs of authoring these data will be higher than those of conventional publications. Without visible incentives, it will be difficult to convince both industry and the Services to implement these capabilities.

d. If action is not taken in the very near future to develop and implement data exchange standards for technical publications, Service and industry systems will have evolved to the point that many of them will have to be "washed out" in order to implement such standards. This would tend to increase the normal tendency to object to change.

e. Resistance to integration of traditionally separate functions, such as training data development with maintenance data development, and IPB/RPSTL data with Provisioning Technical Documentation will be encountered on the part of both performing and responsible management organizations.

## **2. IDENTIFICATION OF CANDIDATE FUNCTIONS**

**2.1 Candidates for Automation.** Candidate areas for automation include, (a) industry publication development and production activities, and (b) Service/DoD archiving, updating and distribution systems.

**2.2 Candidates for Standardization.** Candidates for standardization include publications data exchange formats (near-term), data delivery formats for interactive maintenance aids (long-term) and computerized systems (including hardware, software and media) for use by the Services in receiving, archiving, updating, and distributing publications data. It should be noted that all service systems cannot be standardized, due to different maintenance environments.

However, this does not mean that none of the systems can be common or that they cannot accept standardized data delivery formats.

**2.3 Candidates for Integration.** As discussed in paragraphs 1.1 and 1.2.3, candidate areas for integration include data exchange formats, LSAR/PTD/Publication interfaces and Service computing system development activities.

### **3. ANTICIPATED RECOMMENDATIONS**

**3.1 Funding Issues.** Near-term funding will be required in order to take advantage of current industry investment plans, maximize return on investments being made in Service systems and to lay the foundation for longer-term advances. Funding these activities will require that they be given a high priority within DoD. The fact that the majority of savings to be had in this area is in the form of cost avoidance rather than cost savings will not make its funding any easier. Prioritization of this funding should be as follows: first, development of near-term data exchange formats; second, development and implementation of service systems to receive, distribute, archive and update computerized publication data; and third, development and demonstration of data authoring capabilities for interactive maintenance aids.

**3.2 Incentive Issues.** Near-term industry incentives will be provided by the continuing pressure to improve productivity and reduce costs. Development of a standard data interchange format will assist in directing industry investment toward systems that can communicate with those of the Services.

Near-term service incentives are more difficult to define. As discussed in paragraph 1.4, to weapon system developers and managers, implementation of near-term capabilities will appear to be simply additional costs. The only effective incentive for

them will be a continuing high level of management emphasis and adequate funding.

Longer term incentives will have to be provided through Service commitment to and funding of development and fielding activities for interactive maintenance aids.

**3.3 Contracting Issues.** Contracting issues that must be resolved include methods of performing quality assurance checks on electronic data, desire on the part of industry for cost sharing on initial contracts where improved capabilities are contractually specified, development of means for performing data validation/verification activities and the ability of small/disadvantaged business to perform data preparation and update activities.

**3.4 Specification and Standards Issues.** Specifications and standards issues include development of suitable data delivery formats, standardization of those formats throughout the Services and validation of their implementations. The issue of standardized formats for all Services is particularly important, as it can minimize the number of interfaces and translators that must be developed, validated and maintained.

**3.5 Technological Changes.** Three major technological developments are expected to impact the technical publication function in the near future. These developments include more capable and less expensive interactive graphics systems (IGS), integrated text and graphics authoring systems and scanning capabilities. The IGS advancements will work to the near- and long-term advantage of the publications function. IGS systems are now available that can significantly lower the cost of developing and modifying graphics for use in technical publications. In the near future, lower cost IGS systems that can exchange data with CAD systems will be available. Implementation of these systems will serve to further lower the number of man-hours required to produce a publication

page. Integrated text and graphics authoring systems (known as "what-you-see-is-what-you-get" or WYSIWYG systems) offer the potential of another significant improvement in manpower costs. Unfortunately, since they are primarily oriented to development of page oriented data, they will work to the disadvantage of efforts to implement authoring systems for development of interactive maintenance aid data. Scanning technology offers the potential of an inexpensive method of "digitizing" data that exists only in hard copy form. Scanning capabilities have advanced rapidly in the last few years and show no sign of slowing down in the near future. Development of a capability to digitize existing technical publications data could significantly ease the difficulty of transitioning technical publications functions from paper to digital mediums.

In the longer term, the development of portable, rugged, computers to host interactive diagnostic and data delivery systems will be required.

**3.6 System Characteristics.** Two primary issues exist that are related to computer system characteristics. These issues are security of classified material and configuration control of electronic data. Security of classified data when stored in a digital format (and especially when subject to TEMPEST requirements) is an obvious problem. To date, the means utilized to overcome this difficulty has been to isolate the computer system containing the data and restrict access (both physical and electrical) to it. Presently, this solution is merely inconvenient. In the future it will be unacceptable, as it would reduce the update and distribution advantages that automation of the process is intended to achieve for some of the most important data. The second issue, that of configuration control, is no less important. In order to effectively manage technical data, configuration control must be maintained. An elaborate system for controlling the configuration of paper-based publications has been developed over

the years. A similar capability for digital publications data will have to be developed and implemented. In addition to management needs, safety is also a consideration, particularly as it applies to maintenance of nuclear weapons.

**3.7 Policy Issues.** The following policy issues exist with regard to computerization of the technical publications process:

First, and probably the most controversial, is the appropriate role of government activities in the creation and update of technical publications data. There is considerable concern within industry that, in order to justify the existence of Service computing systems associated with technical publications, the traditional role of industry in preparing and updating technical publications will be taken over by the Services. At the opposite end of the spectrum, some in industry have suggested that DoD should contract for all data development, maintenance and access, thereby avoiding the need to develop any organic data maintenance capabilities.

The second policy issue that must be addressed is that of the appropriate role of the GPO and independent printing contractors as the Services make a transition from paper to computer-based technical publications. Clearly this transition is going to reduce, and eventually eliminate, their traditional roles.

Prioritization of publications system improvements within the Services is the third significant policy issue. As discussed in previous sections, it will be necessary for the Services to commit a significant amount of funding to making the paper-to-digital media transition. In light of the traditional reluctance to make support improvements a high priority, it will probably be necessary to develop and implement some high level policy direction in this regard.

A fourth issue will be the need for integration of the various Service efforts, in order to minimize the number of interfaces between them and industry. Lack of standardized

interfaces will add to the cost of computerizing the publication process and impede transfer of data between the various systems.

Effective feedback of field experience into publications is an issue that each Service will have to establish as a priority. The opportunity to improve publications usability will be provided through reduced (or at least contained) update costs and shorter flow times. These advantages can only be capitalized upon if each Service puts into place an effective program of field experience feedback, analysis and incorporation. This, more than any other consideration, will determine the near term usefulness of publications as fault isolation aids.

#### **4. JUSTIFICATION FOR THE CHOICE OF CANDIDATES**

**4.1 High Payoff.** Computerization of the technical publication process offers high payoff opportunities in a number of areas. The most significant of these is simply the opportunity to continue operations in a reasonable manner. The process of developing, distributing and maintaining paper-based technical publications has become so unwieldy that its continued viability is in doubt. The existing structures have been stretched nearly to the breaking point by increased page counts, higher costs, longer flow times, increased number of publications and funding realities. As discussed in previous paragraphs, significant cost payoffs are also available. These payoffs include (1) reduced (or contained) data acquisition costs through continued industry automation, (2) lower future change costs through availability of high quality electronic source data, and (3) improved weapon support through timely data update, faster distribution, and reduction (or elimination) of change page insertion.

**4.2 Feasibility.** The feasibility of computerizing the technical publications function is not in doubt. The majority of the technology needed to make near-term improvements is mature

and available either off-the-shelf or with little development. Its cost-effectiveness is demonstrated by the considerable implementation of computerized capabilities that has already occurred within industry, and the number of Service development/feasibility demonstrations that are underway. The primary challenges will be the integration of the necessary capabilities into appropriate hardware and software packages. The decision is not one of whether improvements are feasible, but one of how they should be implemented. Implementation is currently in progress, what is needed is DoD/Service focusing and direction of the effort.

**4.3 High Leverage.** High leverage of this activity is available due to the significant investment that industry has made and is planning to continue. Additional leverage is provided by the ability to integrate much of the effort that is being accomplished as a part of the various Service efforts.

**CALS FUNCTIONAL DESCRIPTIONS**  
**CONTRACTOR FUNCTIONS:**

**11. IDEF A34, CALS Utility for Test and Evaluation**



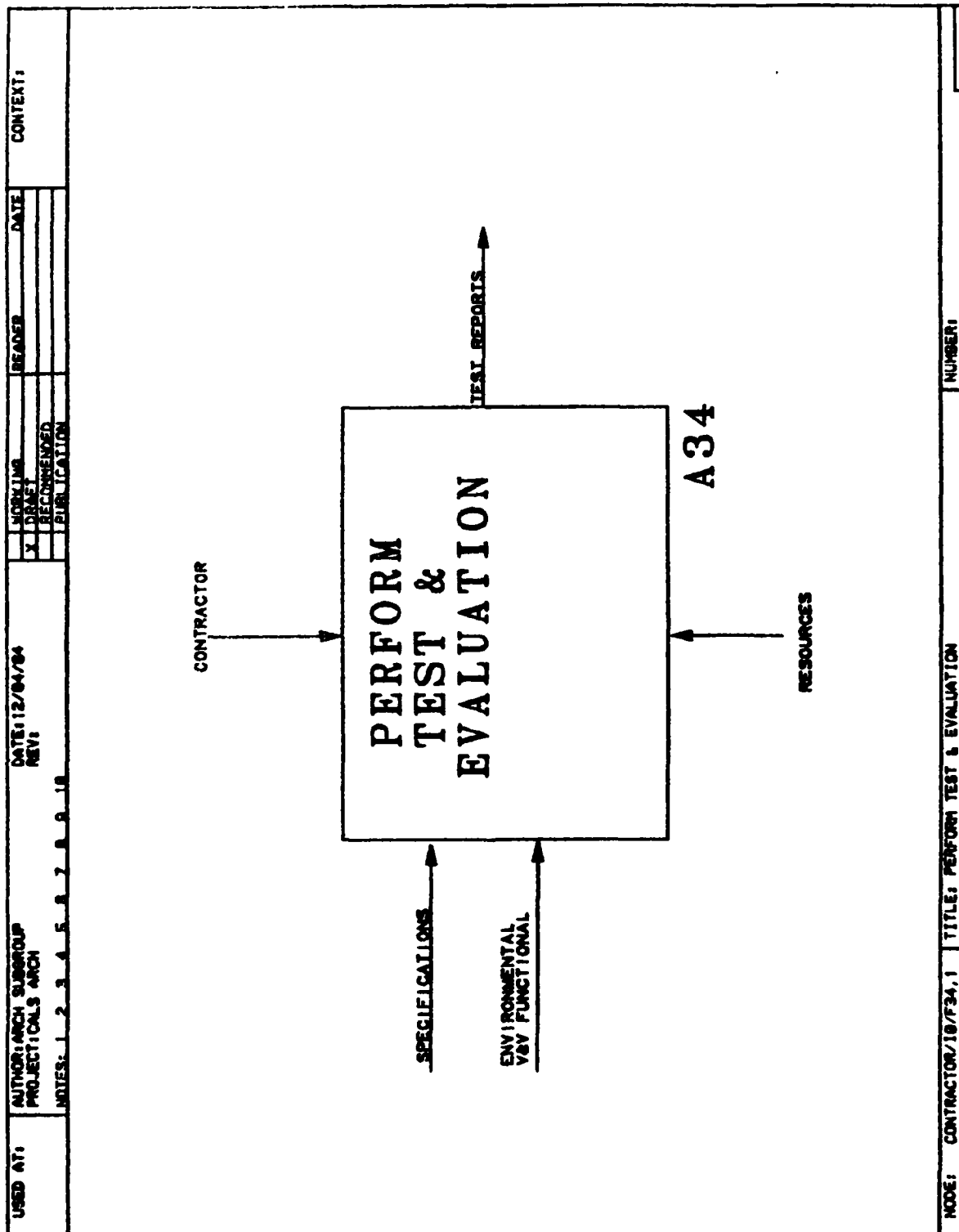


Figure 2-21. IDEF A34, PERFORM TEST AND EVALUATION, CONTRACTOR

A34 Perform Test and Evaluation

Glossary

Contractor - The agency that built the item being tested.

Specifications - Contractual performance and test requirements.

Personnel - Test personnel.

Resources - The tools, test equipment, facilities etc. required for test and evaluation.

Test Plan/Procedures - Formal plans and procedures for the conduct of test and evaluation.

Government Reps. - Personnel representing the Government to monitor and/or conduct the tests.

Test Data Results - Documented results of the tests.

Environmental V&V - Results of validating and verifying operation and maintenance procedures to address various environmental conditions.

Personnel, Logistics Support, Hardware, Software - Test resources.

Test Reports - Contractual documentation containing the test results.  
Usually a formally specified data items.

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graph TD
    SPEC[SPECIFICATIONS] --> PLAN[PLAN TEST  
A341]
    PLAN --> CONDUCT[CONDUCT TEST PROGRAM  
A342]
    CONDUCT --> EVAL[EVALUATE TEST DATA/RESULTS  
A343]
    EVAL --> REPORTS[TEST REPORTS]
    
    PLAN --> COST[COST CONTROL]
    PLAN --> SCHED[SCHEDULE CONTROL]
    PLAN --> CONTRACTOR[CONTRACTOR]
    
    CONDUCT --> GOV[GOVERNMENT REPS.]
    CONDUCT --> ENV[ENVIRONMENTAL V&V FUNCTIONAL]
    CONDUCT --> LOG[PERSONNEL LOGISTICS SUPPORT, HARDWARE, SOFTWARE]
    
    EVAL --> PERSONNEL1[PERSONNEL]
    EVAL --> RESOURCES[RESOURCES]
    EVAL --> TEST_PLAN[TEST PLAN/PROCEDURES]
    TEST_PLAN --> CONDUCT
  
```

The flowchart illustrates the test process, starting with **SPECIFICATIONS** leading to **PLAN TEST** (A341). This step involves **COST CONTROL**, **SCHEDULE CONTROL**, and the **CONTRACTOR**. The plan then leads to **CONDUCT TEST PROGRAM** (A342), which involves **GOVERNMENT REPS.**, **ENVIRONMENTAL V&V FUNCTIONAL**, and **PERSONNEL LOGISTICS SUPPORT, HARDWARE, SOFTWARE**. The results of the test program are then **EVALUATED** (A343), leading to **TEST REPORTS**. The evaluation step also involves **PERSONNEL** and **RESOURCES**, and feeds back into the **TEST PLAN/PROCEDURES**, which in turn informs the **CONDUCT TEST PROGRAM**.

## IDEF A34 CONCEPT PAPER

### CALS UTILITY FOR TEST AND EVALUATION

#### 1. FOCUS OF CALS IMPLEMENTATION

1.1 Overview. To satisfy a Government requirement, the contractor must demonstrate that the proposed approach satisfies the needs of the contract. This is accomplished through various test and evaluation efforts. The two areas in which the contractor directly participates in the testing of the proposed equipment are the contractor's own test and evaluation and the procuring activity's technical evaluation. The contractor's test and evaluation consists of two efforts: he is required to demonstrate that the system/equipment will satisfy the environmental requirements, as described in the specification, and he must perform complete functional testing which is intended to prove that the system/equipment does, in fact, operate as required. The technical evaluation performed by the procuring activity, in which the contractor also participates, is essentially a functional test in a dynamic environment.

The testing efforts should be synthesized early in the design cycle to ensure that the logistics efforts are properly integrated, specifically in the areas of diagnostics, reliability, and maintenance. Ideally, the contractor will use Computer-Aided Design with the application of artificial intelligence to exercise the design on the system/equipment level in order to determine if any system-related software/hardware interface problems exist. With artificial intelligence computers, the design will be stressed against the system requirements and any shortcomings will be identified. These shortcomings will be synthesized by the computer and recommendations on what corrective action should be taken will be identified. This approach will be from the printed circuit board level, through the assembly, all the way up to the system level.

This approach will be used to interact with failure modes and criticality effects analysis and sensitize the design to stress all of the critical components in order to determine the failure impact. It also will be used to assess risk in compliance with specified requirements.

The deliverables normally required by a contract include a complete set of test plans and procedures. These will also be generated by the computer using the inherent knowledge created while designing and modifying the equipment/system. The appropriate formats for the plans and procedures will reside in the computer and, when initiated, be prepared in hard copy and available for review. This review will be performed initially by the contractor and then transmitted by computer-to-computer to the developing agency for review. Once approved, the developing agency would transmit its comments back to the contractor via the computer link.

During the actual quality assurance testing, the computer will simulate all of the proper signals required to exercise the machine to determine any shortcomings in the design. These test signals will then be created for the test environment. Any ambiguities found by these tests as monitored by the computer also will be reported. All workarounds and self-healing techniques will be exercised to ensure that the built-in tests can be successfully completed. A report will then be computer-generated and forwarded to the developing agency for review.

**1.2 Likely Payoffs and Benefits.** Several immediate benefits would be realized using this application. There will be immediate recognition by the contractor of possible problems that can occur during the design and development testing of the system/equipment. Techniques to determine reliability weak points may then be exercised and rapid corrective action taken to satisfy the supportability requirements. Failures that occur

during testing will be rapidly identified and the degree of impact measured so that actual system performance can be determined. All types of signals could be employed and variations in design determined prior to testing in a live environment. The subjective evaluations by Government and industry will be minimized and/or eliminated and disputes on system successes/failures would be nonexistent. The benefits of such a system can include:

- a. Diagnostics will be performed and thoroughly checked out prior to complete system design, thereby eliminating costly redesign and remanufacture.
- b. Standardized formats for all test plans and procedures will be ensured.
- c. Techniques to test the system will be based upon the smart computer system engineering systems approach developed at the onset of the program rather than attempting to generate a document that does not fully satisfy the contract requirements.
- d. System design history would be readily available and accessible for use in design evaluation.
- e. Future designs of similar requirements will be enhanced as new components are integrated to replace obsolete or out of production devices. Rapid system quality determination also will be a major logistics benefit. The computer would be capable of recognizing logistics shortfalls, reviewing the LSAR to ensure that appropriate parts are ordered, making changes to the technical manuals and training materials, and making necessary changes to the maintenance approach.

**1.3 Changes Needed and Anticipated Problems.** Currently, on-line, real-time testing capabilities in new systems are usually not available at the time of quality assurance testing. Nor have the candidate systems been adequately analyzed to ensure that as many problems as possible have been identified and designed out of the system. Faster computer processing is required plus additional capability for designing and implementing back ups, workarounds, and similar techniques.

Standardization to provide software interfaces which will ensure the availability of compatible global data communications

is required so that problems encountered during technical evaluations may be addressed in real time.

## **2. IDENTIFICATION OF CANDIDATE FUNCTIONS**

Computer-developed test procedures should be employed for the test and evaluation program. This would serve to validate procedures as well as equipment; the procedures should then be used in the technical manuals.

## **3. ANTICIPATED RECOMMENDATIONS**

**3.1 Funding Issues.** In order to successfully adapt CALS to government T&E, testing requirements must be integrated with budgeting and financing procedures. Methodologies for accurate and early T&E cost forecasting are required and a formal feasibility study of the automation of DT&E/OT&E test procedures should be undertaken as soon as possible.

**3.2 Incentive Issues.** Accelerated development of CALS for T&E requires funding for exploratory development of T&E areas requiring state-of-the-art advancement and for concept formulation efforts.

**3.3 Contracting Issues.** The major contracting issues will result from the use of obligatory standard computerized Support Acquisition and Management techniques which will impact upon contractual regulations. The Government should be able to gain the necessary competitive leverage with the potential contracting sources by invoking a requirement for automated Test and Evaluation procedures on certain specific Requests for Proposals (RFPs). Although there are other methods, this would probably be the most cost-effective means to provide the necessary incentive for contractors to adopt CALS techniques. It also should be the most direct and timely alternative which the Government can employ to use CALS to improve T&E procedures.

**3.4 Specifications and Standard Issues.** Specifications and standards issues must be addressed at the outset to prevent a proliferation of independent, standalone models--a condition which would inhibit, if not prevent, interoperability among potential users. One way to ensure compatibility will be to retain the manual procedures for T&E while transitioning to CALS. This will permit existing specifications and standards to be modified/adjusted concurrent with the preliminary development of automated programs. This also will allow the Government to obtain the maximum utilization from the numerous "personal computers" already in use, while transitioning into the networking of computers.

**3.5 Technological Changes.** The projected advances in computer technology, data management and exchange techniques, and communications methods should encourage the rapid introduction of an automated Test and Evaluation support concept for both Government and industry.

**3.6 Policy Issues.** Government imposition of contractual obligation on industry to comply with approved standards for system development is now an accepted provision of DOD policy. Therefore, requiring industry to implement standard computerized T&E support techniques during systems development should not require any significant modification to the DOD systems acquisition policies.

#### **4. JUSTIFICATION FOR THE CHOICE OF CANDIDATES**

**4.1 High Payoff.** The T&E candidates for automation will provide the opportunity for substantial cost benefits in terms of:

- paper reduction,
- improved data accuracy, and
- improved data availability.



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REPORT OF THE JOINT INDUSTRY - DOD TASK FORCE ON  
COMPUTER AIDED LOGISTIC (U) INSTITUTE FOR DEFENSE  
ANALYSES ALEXANDRIA VA F R RIDDELL ET AL JUN 85

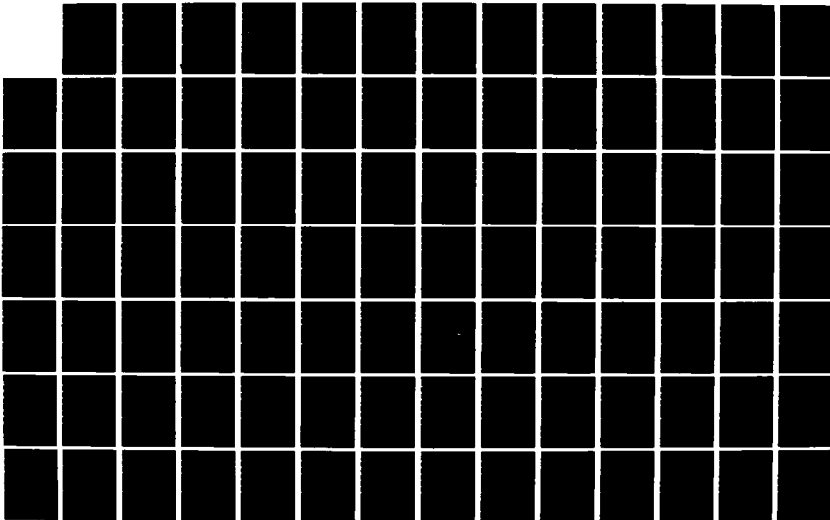
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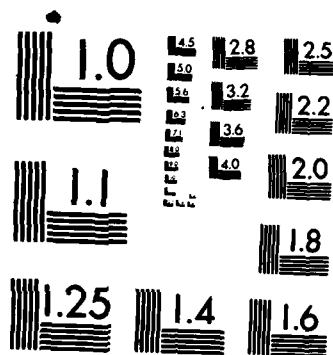
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MICROCOPY RESOLUTION TEST CHART  
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Cost benefits in paper reduction alone will justify automating T&E procedures for systems support. In addition to the savings by reducing and/or eliminating reports, plans, etc., a potential exists for significant reduction in the cost of filing and sorting paper documents.

**4.2 Feasibility.** The concept of fully automated techniques for T&E procedures is well within the realm of functional feasibility, given the present state-of-the-art electronic data processing technologies.

**CALS FUNCTIONAL DESCRIPTIONS**

**CONTRACTOR FUNCTIONS:**

**12. IDEF A35, CALS Interaction With Manufacturing**

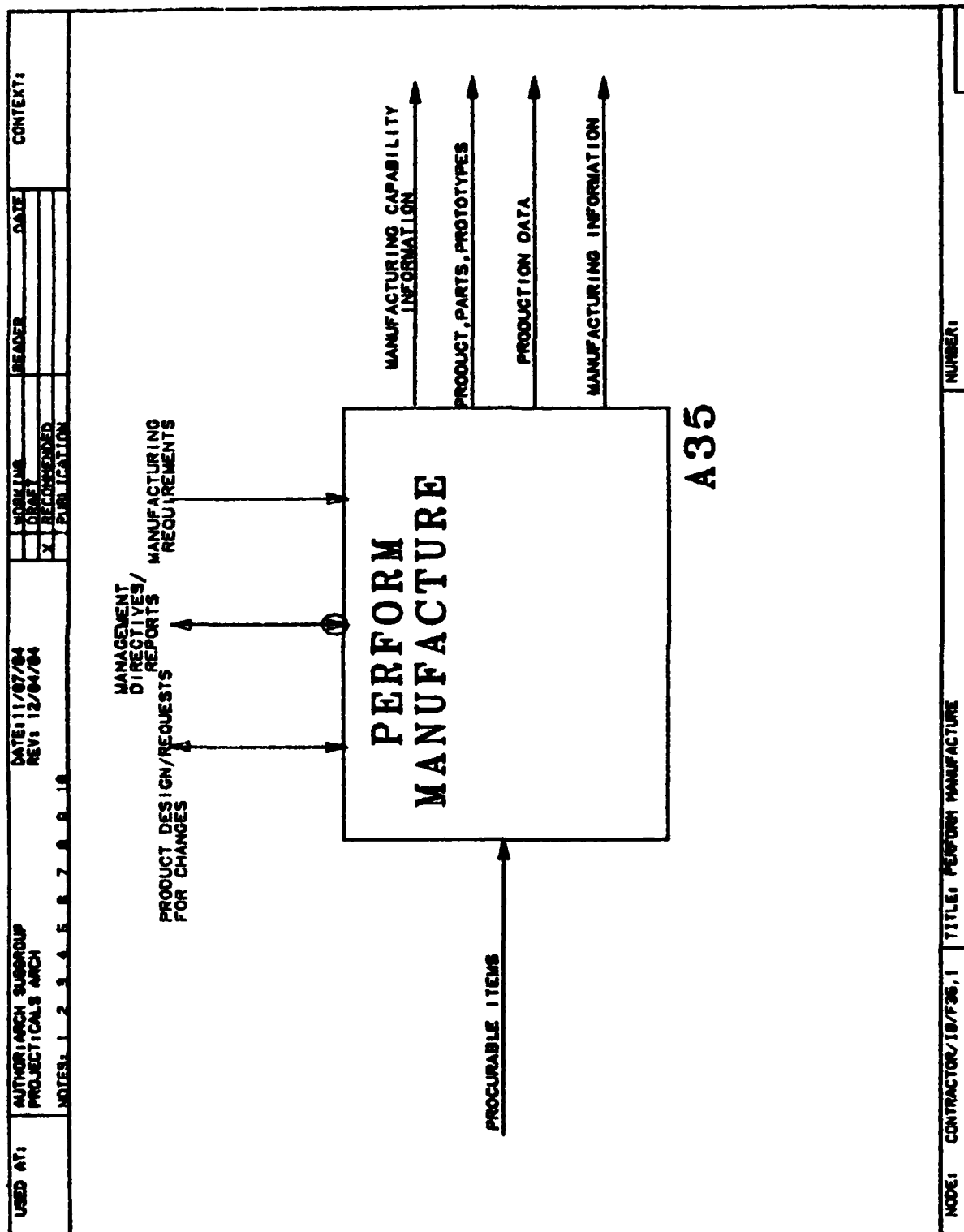


Figure 2-23. IDEF A35, PERFORM MANUFACTURE, CONTRACTOR

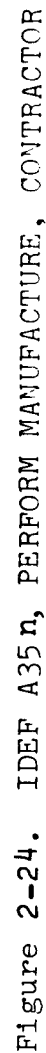
A35 Perform Manufacture

The primary input is "Procurable Items" - the things that are bought or given to the manufacturer (e.g., sheet metal or engines), to be incorporated in the output or used in its manufacture (drills). Implicit also is the sum total of previous knowledge which will be used in decision making.

The primary control is the product design, and the primary outputs are the product themselves. Support systems, parts and prototypes.

Other controls are the manufacturing requirements and the management directives, corresponding reports. To unclutter the subsequent diagrams, the "Directives/Reports" arrows are not drawn, but must be understood to be present. The parentheses at the arrow head show this implicit existence.

The primary output is the product and other manufactured items (parts, kits, prototypes). Other outputs are information useful to planning, field support, and design.



### A35n Perform Manufacture

There are two "planning" activities shown on A35; Box A351 "Plan for Manufacture" and Box A353 "Plan Production". The first relates to the strategy of producing the total product - the major subdivision of the equipment structure, the basic method of manufacture, and the trade-offs to optimize facilities requirements, cost, and time schedules. The second relates to the strategy of producing the individual parts - the route sheets, operation sheets, and the list of machine tools, forms and cutters, fixtures and gauges required.

There are two "provisioning" activities shown on A35; Box A354 "Provide Production Resources" - facilities, equipment, tools, and people; and Box A355 "Obtain Manufacturing Materials" - those items which will ultimately be included in the delivered product.

There is an administrative activity; Box A352 "Make and Administer Schedules and Budgets". This activity produces those schedules and budgets which provide proper coordination between the separate activities of Boxes A353, A354, A355, and A356.

Finally there is "Produce Product". This is where the form and character of materials are altered and the pieces assembled.

### Glossary

**Product Design** - Includes both preliminary and final engineering design. The preliminary engineering design as well as the final is available to Box 1. The engineering release itself and change orders are used for Box 3 planning production. The Engineering Design also includes identification of long lead items for which early procurement is required.

**Product Manufacturing Requirements** - Includes the date and rate of delivery requirements as well as requirements on how to obtain things. The dates of delivery are needed for schedules or budgets and the other requirements are used for the manufacturing plan (Box 1).

**Manufacturing Plans** - These are overview plans which include flow sequence plans, item and station charts, item indentures, facilities and equipment requirements, manpower requirements, tooling requirements, material requirements, etc.

**Material Plan** - A plan for acquisition of all of the different things that must be procured to go into the product, including general principles as well as specific items.

**Schedules** - These phasing of production plans, resources, materials, and production itself. These schedules accomplish the coordination of Boxes 3, 4, 5, and 6 and allow them to operate essentially independently. The schedules typically include start and completion dates for major items dealt with by each subfunction.

**Budgets** - The allocations of funds for each of the major sub-activities.



**A35 Glossary (Con't)**

**Special Schedule Requirements** - Most items are scheduled according to standard flow times. Any deviation from that is a special schedule requirement.

**Special Tool Identification** - The identification of tools that are needed and the part for which they are needed.

**Manufacturing Indentured Parts List** - The completion or extension of the manufacturing parts list as produced by production planning. It is primarily needed for scheduling purposes (among other).

**Resource Characteristics** - The characteristics and capabilities of the facilities, the equipment, people which are available or specially obtained for this product.

**Production Instructions** - The detailed description of the operations and processes that must be carried out to produce any given item, including the routing in which they are to be carried out.

**Procured Item Specification** - Detailed specification of any item which is to be obtained from outside of the company.

**Tools Specification** - The detailed specification of a tool (which must be procured or fabricated) to be used in producing the product.

**Purchase Requisition (as shown in Box 4-5)** - Are requisitions to obtain items to be used in making of facilities, equipment or tools.

**Stores Requisitions (from Produce Product)** - Are the requisitions (1) for materials obtained to be used in making the product or of resources particularly requisitioned or (2) for tools for making the product. These are requisitions for the item to be supplied as opposed to being obtained.

**Manufacturing** - The conversion of a design into a finished product. Manufacturing then includes planning, scheduling, and getting whatever necessary for the actual making of the product.

**Production** - The actual making, the physical act of doing what is necessary to make the product. Includes altering the form of materials, assembling, and testing.

**CALS FUNCTIONAL DESCRIPTIONS**  
**CONTRACTOR FUNCTIONS:**

**13. IDEF A36, Providing Logistics Systems**

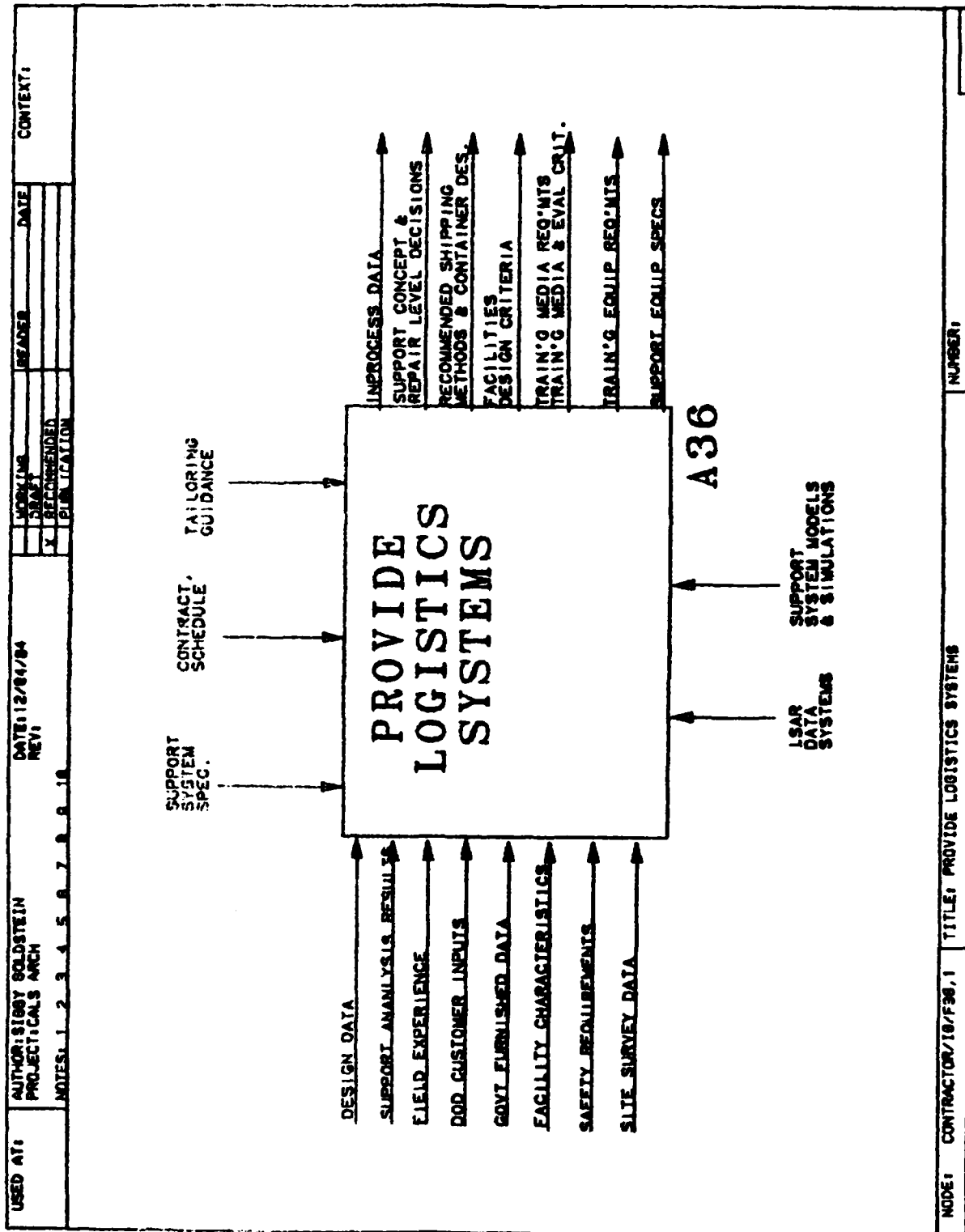


Figure 2-25. IDEF A36, PROVIDE LOGISTICS SYSTEMS, CONTRACTOR

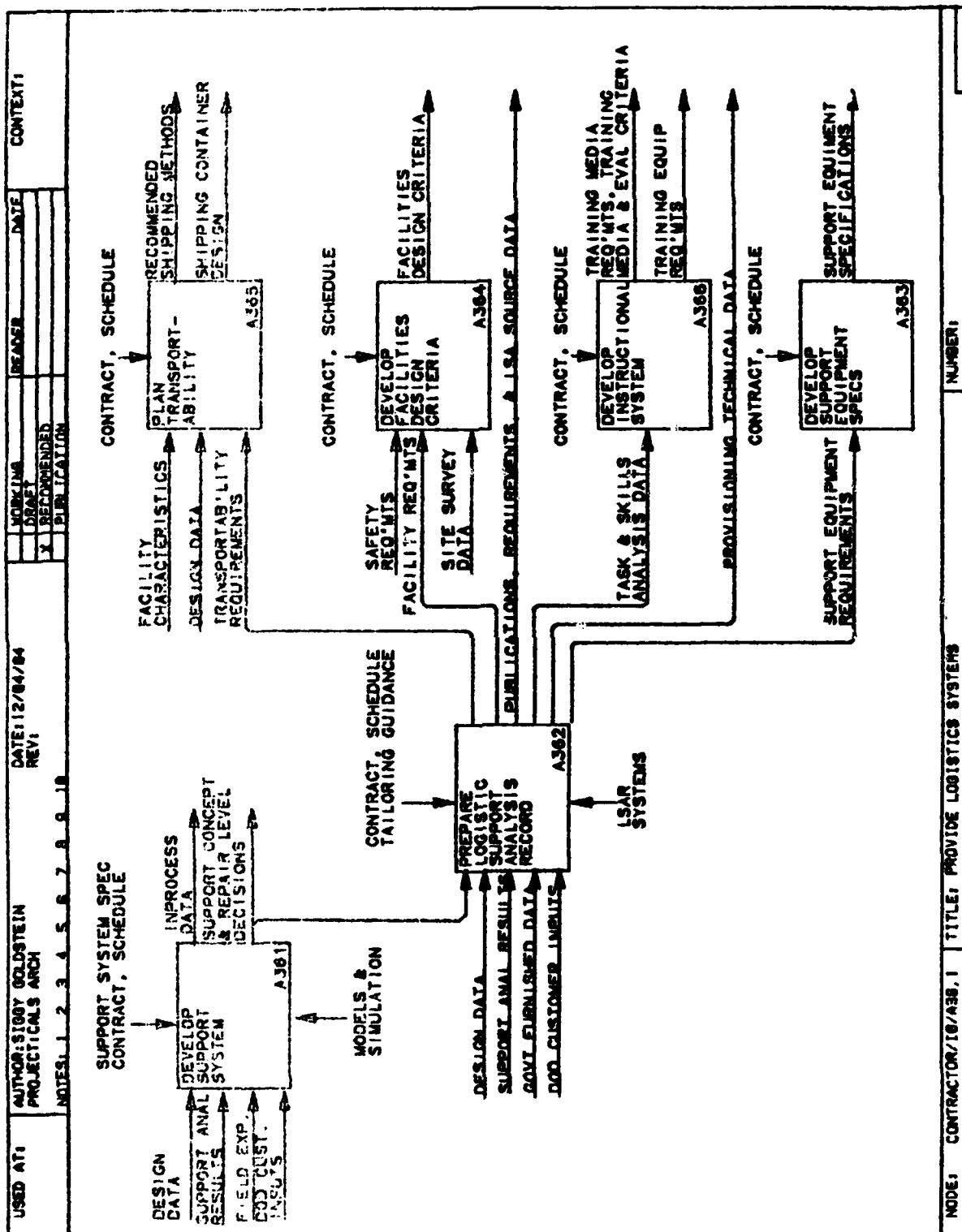


Figure 2-26. IDEF A36n, PROVIDE LOGISTICS SYSTEMS, CONTRACTOR

IDEF A36 CONCEPT PAPER  
PROVIDING A LOGISTICS SYSTEM

1. FOCUS OF CALS IMPLEMENTATION

1.1 Projected Performance of the Target Computerized Functions

Future support planning and acquisition activities will not functionally differ in any significant manner from those of the present. Rather, the differences between present and future activities will be the high degree of integration between the various activities, their integration with the design process, the interactivity of their processes and the degree of their automation.

Support system development activities will be accomplished with the use of computerized models that are capable of interacting with the user, other support analyses, various government data sources and with the design process. The result will be development of improved support strategies and improved feedback of support requirements into the design process. The ability to access and utilize various government data sources during this process will also assist in the process of developing support systems and strategies that more closely fit the system user. Interactive models will also allow alternative support strategies to be quickly evaluated.

Once the most appropriate support system strategy has been selected, the LSAR data base will automatically be structured based on the repair level and repair/discard decisions made during the support system development process. Data from other support analyses, design activities, industry data bases and government data bases will also be automatically or semi-automatically loaded. Manual addition or manipulation of LSAR data will be kept to a minimum, but where necessary will be performed in real time on an interactive basis. The outstanding features of future LSAR data systems will be: (1) their ability

to relate to and interact with design data through a common indexing structure, (2) rather than being in addition to other logistics planning data requirements, they will be the logistics planning data (thus, rather than acquiring PTD, SERDS, LSAR, etc., only LSAR data would be acquired), (3) users of the LSAR data (including DoD components) will access needed data directly from an on-line data system rather than by requesting hard copy reports, and (4) instead of being all encompassing, LSAR data requirements will be tailored to the item or system being procured.

As a result of the reduced flow times and improved usability of the support system planning and LSAR data, support acquisition activities, including technical publications development, the instructional system development process, spares provisioning activities, support equipment specification development, development of facilities design criteria and transportability analysis will obtain their requirements directly from the LSAR data base.

## **1.2 Implementation Considerations.**

**1.2.1 Technical Considerations.** It is presently possible to model and simulate the operation of various support strategies and support system configurations using high-order computer simulation languages and powerful mainframe and super mini-computer hardware. These tools can be of great benefit when properly utilized. Their deficiency is that they are stand alone, frequently are not interactive, are manpower intensive and time consuming to develop and expensive to utilize. Improvement of support system design and trade-off activities will require that these techniques be integrated with other design and support analyses, that they be made interactive with the user, that the cost and difficulty of developing and using them be lessened, and that the means be developed for them to exchange data with the

design and LSAR functions. Implementation of improved modeling and simulation capabilities will do for support system design what spreadsheet programs have done for business management: allow near real-time, interactive evaluation of various alternatives. Making them interactive with the design process will allow for near simultaneous optimization of design and support system configurations. Areas that pose significant technical challenges include (1) development of appropriate modeling algorithms, (2) development of even higher level simulation languages, and (3) development of mechanisms to interface support system models with other support analyses and the design process.

Integration and interaction of support system development and acquisition activities with those of the design process will require that some means be developed to relate the various types of support data to each other and to the design process. The two factors that must be addressed in order to do this are data formats (number and type of characters) and data structures (indexing). One concept for doing this has been advanced by the Air Force with its Functionally Integrated Designating Reference (FINDER) concept. Without this common indexing structure, it will be impossible to obtain and relate data from all of the various sources.

Improvement of the LSAR development process will require that all of the LSAR data be automated and that the processes associated with its development and update be both interactive with the analyst and occur at near real time. On-line LSAR data systems have been developed in the past, but have generally been oriented toward development and delivery of hard copy LSAR products, rather than the on-line delivery of information, and the preparation of the complete range of logistics data requirements. The expense associated with establishment and operation of these on-line systems (which are usually mainframe computer based) has to a large degree precluded their use by

second and third tier DoD suppliers. Interactive, real time LSAR systems must be developed and implemented. Along with this, a means must be developed to provide second and third tier suppliers with access to these capabilities. The most obvious way to do this would be through the development of LSAR systems that utilize mini/micro computer technology and possibly fourth generation languages rather than mainframe computers and second or third generation languages.

Computer-aided processes for use in accomplishing the various support acquisition functions will also have to be developed. Some efforts have been made to automate processes within these functions, but little attention has been directed at their standardization or integration with the LSAR. In addition, the majority of the internal process automation has been of batch or transaction oriented methods rather than on-line, interactive capabilities.

Data security for classified data will also be a significant technical issue that must be dealt with.

**1.2.2 Contractual Issues.** Contractual issues will center primarily around the cost of developing, implementing and supporting the improved capabilities that are described in paragraph 1.1. To the extent that they are perceived by industry as a necessary cost of doing business, they will be developed and implemented at industry expense. Where they are perceived as adding additional cost or being required as a part of a particular procurement, industry will probably expect their costs to be funded, or at least shared, by the requiring DoD component.

Other contractual issues that will require resolution include how costs for data preparation, maintenance and access should be allocated, how quality assurance and delivery requirements for digital data can be satisfied and how proprietary rights to data can be protected.



**1.2.3 Integration Issues.** The most significant integration issue is that of the various data requirements. Present logistics standards and data item descriptions contain large overlaps and gaps, are not oriented toward computerized production and are often managed by separate organizations. Integration of the data requirements of these DIDs into a single comprehensive set of logistics data requirements would eliminate such inefficiencies as procurement of Ground Support Equipment Recommendation Data (GSERD) and LSAR "E" record data at the same time.

A second integration issue is that of activities that have traditionally been established and managed as separate entities. This includes functions such as preparation of Provisioning Technical Documentation (PTD), identification of technical manual requirements, preparation of Illustrated Parts Breakdowns (IPBs) or Repair parts and Special Tools Lists (RPSTLs) and the instructional system development process. The common elements of these activities must be integrated and incorporated into the LSAR development process.

Other integration issues that must be addressed include integration of design and logistics data requirements and development of the means to relate design and logistics data.

**1.3 Likely Payoffs and Benefits.** The integration and automation of support planning and acquisition processes would produce the following benefits: (1) improved readiness and lower operation and support costs through development of more optimum support systems and strategies, (2) lower data acquisition costs through the use of automated processes, integration of data requirements, access to various government data sources and timely feedback of field experience data, (3) improved access to needed data by both industry and DoD activities, (4) improved ability to quantify the impact of design changes on support and readiness,

readiness, (5) improved integration of planning concepts and support data, (6) shorter flow times for support system development and support resource acquisition, and (7) lower support item procurement costs due to better utilization of existing assets and improved requirements development for new support items.

**1.4 Changes Needed and Problems.** The changes that will be required in order to implement the capabilities discussed in paragraph 1.1 include the following:

a. The full range of LSAR data and products must be automated. The present LSAR standards (including MIL-STD-1388-2A) do not provide for full automation of the LSAR data and products.

b. The LSAR data requirements and output products must be expanded to include all of the necessary logistics data requirements and to include additional functions. Additional products that must be provided for include, but are not limited to, Ground Support Equipment Recommendation Data (GSERD), Consolidated Support Equipment List (CSEL), training task and skills analysis data, preliminary work unit code list, LSA candidate list and Calibration Measurements Requirements Summary (CMRS). Additional functions that should be provided for include development of technical manual requirements and tracking of engineering change impacts/incorporation status.

c. A common set of audit trail and configuration control requirements must be established for the LSAR data. Presently each major logistics data item has its own unique configuration control and audit trail requirements. These are usually tailored to the needs of the responsible DoD component or organization. Integration of the logistics data requirements and products are going to require that the configuration control and audit trail requirements be integrated also.

d. A common data indexing structure must be implemented for both logistics and design data. Presently, each major type of logistics data is indexed utilizing its own unique structure. LSAR data are indexed by LSA Control Number (LSACN), provisioning data by Provisioning Contract Control Number (PCCN) and Provisioning List Item Sequence Number (PLISN), field maintenance data by Work Unit Code, depot maintenance data by work order, Defense Logistic Agency (DLA) data by Federal Stock Class (FSC) or Manufacturers Part Number (MPN)/Federal Supplier Code for Manufacturers (FSCM) and design data by drawing or part number. Any attempt to integrate the various logistics data requirements with each other, or with those of design activities, will be complicated or prevented by the lack of a common data indexing structure.

e. Clear guidelines must be developed concerning ownership, location, transition, access authorization and responsibility for maintenance of the LSAR data base. Presently, much of the required logistics data are incrementally delivered and incorporated into various DoD data systems or simply archived in hard copy formats. Each of the various requiring activities and associated contractor organizations maintains their own "data base" with little or no coordination between them. As a result, at any given point in time, no two of the agencies are operating from the same data. In addition, once the system has been fielded, there is no single Service agency responsible for delivery, acceptance, maintenance and preservation of the system's LSAR data base.

f. A DoD-wide capability to provide meaningful feedback of field experience data to both industry and DoD components must be developed. This capability is necessary in order to provide comparison and lessons learned data to weapon system design and modification efforts, provide for efficient weapon system support management and to provide accurate management visibility of weapon system readiness.

The problems that will be encountered in implementing the changes discussed above include the following:

a. Integration of the various logistics data requirements and products into the LSAR will require changes to the way that both industry and DoD components have traditionally performed their functions. The impact of this change can probably be minimized by producing the various deliverable products in their traditional formats, but the effect will still be significant, as it will require all of the various functional organizations to become a part of the LSAR development and update process. Given the tradition, within both the Services and industry of assigning LSAR activities to a single functional organization, considerable resistance to integration of the LSAR data requirements can be anticipated.

b. Appropriate tailoring of LSAR requirement has and will continue to be a problem. As a result of the LSAR data being encompassed by a single standard and a general lack of detailed logistics knowledge by procurement personnel, there is a tendency to make LSAR requirements all encompassing rather than tailored appropriately to each procurement. The decision to create separate DIDs for each MIL-STD-1388-2A output summary is a step in the right direction, but more will have to be done. Consolidation and integration of the LSAR requirements will magnify the cost and schedule impact of imposing untailored requirements.

c. Given the current pressure on the budgeting process, the traditional difficulty of funding support improvements and the fact that many of the benefits will not accrue to the developing organizations, funding for development and implementation of the changes discussed above require a high level DoD commitment and development of firm policy guidelines.

d. The difficulty of changing both industry and DoD design data indexing structures to accommodate needed changes should not be under-estimated. The standards and systems utilized to prepare, release and control design definition data have been built up over the course of many years, and changing them will not be an easy matter. On a broader scale, what is really being requested is a reorientation of design activities to give greater consideration to support requirements.

e. Resistance on the part of industry to radical and/or continual change of the LSAR requirements can be expected. Many contractors made substantial investments in computerized LSAR systems to respond to the original release of MIL-STD-1388. These investments have, to a large degree, been nullified by the development and release of MIL-STD-1388-2A. The reason for this is that the revised standard made significant changes to the LSAR data requirements and structure and most industry systems could not be modified to accommodate them. In order to develop and implement industry LSAR systems that are integrated with those of the design and manufacturing process, flexibility and growth provisions for both data and relational considerations will have to be planned into the LSAR system requirements. Continual additions and changes to the LSAR data requirements will result in LSAR systems being implemented on a "band aid" basis to each project. This type of implementation generally results in a less-than-optimum data system that has few interfaces with other industry systems. In order for industry to develop truly integrated LSAR systems, and DoD components to enjoy the benefits that those systems could provide, a high degree of stability and predictability must be introduced into the LSAR data and data system requirements.

## 2. IDENTIFICATION OF CANDIDATE FUNCTIONS

2.1 Candidates for Automation. As discussed in paragraph 1.1, candidates for automation include the support system development process, LSAR development and reporting process, various support development activities (including instructional system development, facilities design criteria preparation, support equipment specification development and transportability analysis), and Service access to LSAR data.

2.2 Candidates for Standardization. Candidates for standardization include LSAR data requirements and delivery formats. In order to implement integrated LSAR data systems, some additional standardization of the LSAR data requirements and delivery requirements must be made. In the past, LSAR data requirements have varied between projects and Services so greatly that it was virtually impossible to develop a single system for use on all procurements. An important step toward standardizing the LSAR requirements was made with the publication of MIL-STD-1388-2A. This, however, does not mean that all of the problems have been solved. Important questions still remain concerning standardized tri-Service Provisioning Technical Data (PTD) formats, implementation of project and organization peculiar LSAR systems and the acceptability of LSAR outputs as hard copy delivery formats. As logistics systems and LSAR development activities make increasing use of on-line data systems and interactive processes, it will become necessary to develop a standardized method for DoD components to query industry systems. Without some standard method, it would be necessary for Service personnel to be familiar with the structure and operation of each industry system that they need to utilize.

2.3 Candidates for Integration. The primary candidates for integration are the data requirements of the various standards and DIDs. Without this integration, little meaningful progress

can be made toward development and implementation of integrated LSAR data systems, computer-aided processes for support development activities and on-line delivery of logistics planning data.

### **3. ANTICIPATED RECOMMENDATIONS**

#### **3.1 Funding Issues.**

- o Cost of continually changing industry systems.

#### **3.2 Incentive Issues**

#### **3.3 Contracting Issues**

#### **3.4 Specification and Standards Issues**

#### **3.5 Technological Changes**

- o Move from batch language software to neutral data format.
- o Common set of on-line queries.

#### **3.6 System Characteristics**

#### **3.7 Policy Issues**

- o Standardization and enforcement of Service to industry interfaces.

### **4. JUSTIFICATION FOR THE CHOICE OF CANDIDATES**

#### **4.1 High Payoff**

- o Lower data acquisition/preparation costs.

#### **4.2 Feasibility**

#### **4.3 High Leverage**

- o Bulk of effort would be performed and funded by industry.

**Annex 2**  
**CALS FUNCTIONAL DESCRIPTIONS**  
**DoD FUNCTIONS**

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## CALS FUNCTIONAL DESCRIPTIONS

### DoD FUNCTIONS:

#### 1. General

USED AT:	AUTHOR: ARCH SUBGROUP PROJECT: CALS ARCH	DATE: 10/00/84 REV: 12/84/84	WORKING DRAFT X RECOMMENDED PUBLICATION	READER	DATE	CONTEXT:
<div style="display: flex; justify-content: space-between;"> <span>NOTES: 1 2 3 4 5 6 7 8 9 10</span> </div>						

**COMPUTER AIDED LOGISTICS SUPPORT  
ARCHITECTURE  
(CALS)**

EXISTING LOG SYSTEM →

TECHNOLOGY ② →

DATA REQMTS ③ →

**PROVIDE AIDED  
COMPUTER AIDED  
LOGISTICS  
SUPPORT**

(DOD FUNCTIONS)

← CALS ARCH SUBGROUP

**AO**

① DOD POLICY, BUDGET, REQMTS

② POLICY & LEGAL CONSTRAINTS SUBGROUP

③ TECHNICAL ISSUES SUBGROUP

④ DATA REQMTS SUBGROUP

← CALS SYSTEM

PURPOSE: TO DESCRIBE THE FRAMEWORK  
OF A CALS SYSTEM THAT  
WOULD ALLOW DOD TO MAKE FULL  
USE OF CONTRACTOR GENERATED  
DIGITAL DATA

VIEWPOINT: CALS ARCHITECTURE  
SUBGROUP

NODE: DOD/10/A-8,1	TITLE: PROVIDE CALS [CONTEXT]	NUMBER:
--------------------	-------------------------------	---------

Figure 2-27. IDEF A0, PROVIDE CALS, DOD

Table 2-19. IDEF A0, SUMMARY

DOD

A0 Provide Computer Aided Logistics Support

The purpose is to describe the framework of a Computer Aided Logistics Support (CALS) system that would allow DOD to make full use of contractor generated digital data. The focus as described by the CALS architecture subgroup, is the automation, standardization, and integration of the existing logistics system.

Glossary

Existing Log System - An all encompassing term denoting the present way of handling the planning, and data related to the design and acquisition of support resources, primarily hard copy, manually.

Technology - Technical issues related to computerizing all aspects of design influence and logistic support.

Data Requirements - The data and/or information required for design influence and the design, acquisition and preparation of support resources.

DOD Policy, Budget, Reqmts - Constraints placed on the development and implementation of CALS for which the Government is responsible.

CALS Arch Subgroup - The IDA CALS adhoc subgroup assigned to address implementation architecture issues.

CALS System - Computer Aided Logistic Support envisioned as a system concept beginning at the prime equipment design phase and ending at its obsolescence.

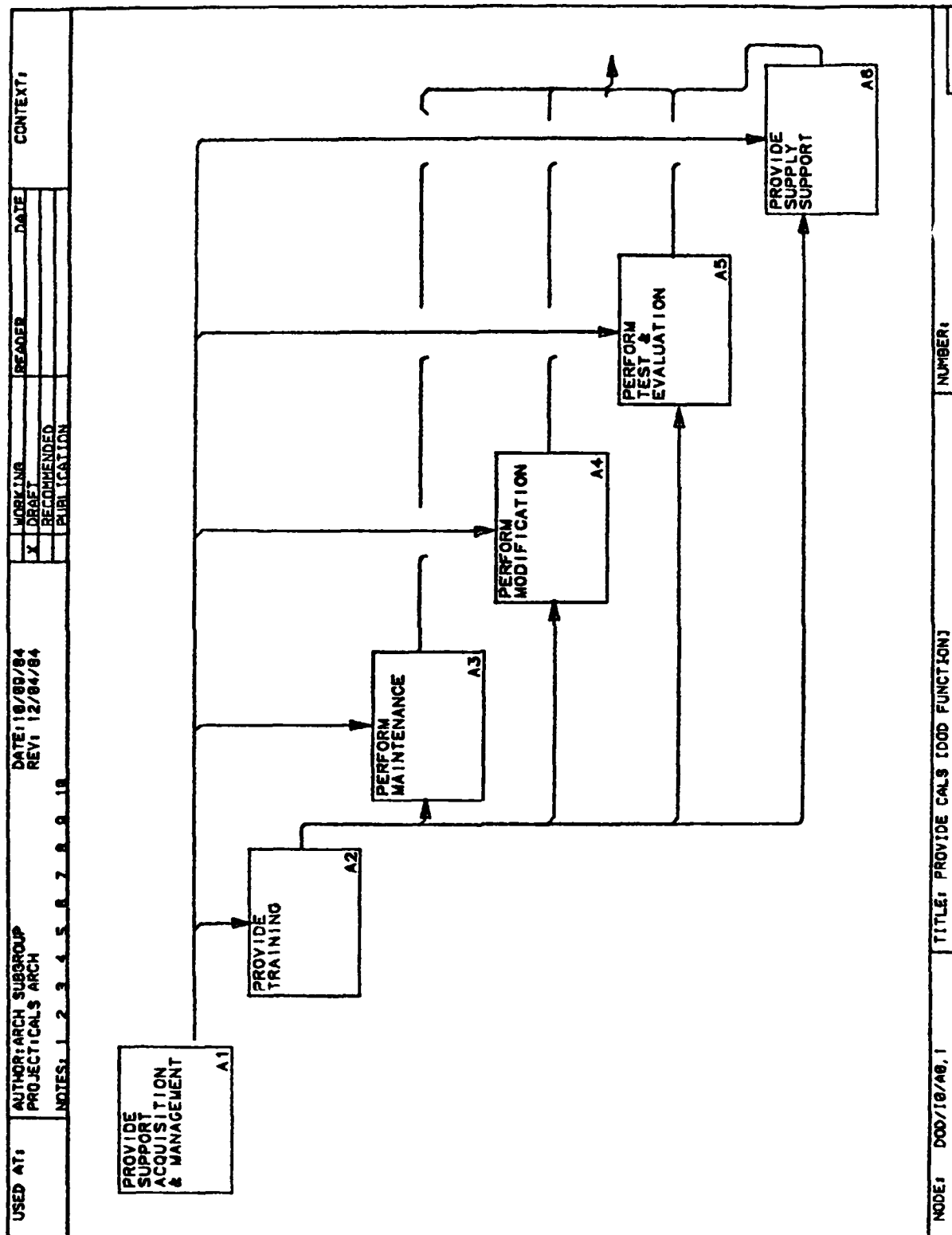


Figure 2-28. IDEF A0n, PROVIDE CALS, DOD

## **CALS FUNCTIONAL DESCRIPTIONS**

### **DoD FUNCTIONS:**

#### **2. IDEF A1, CALS for Support Acquisition and Management**

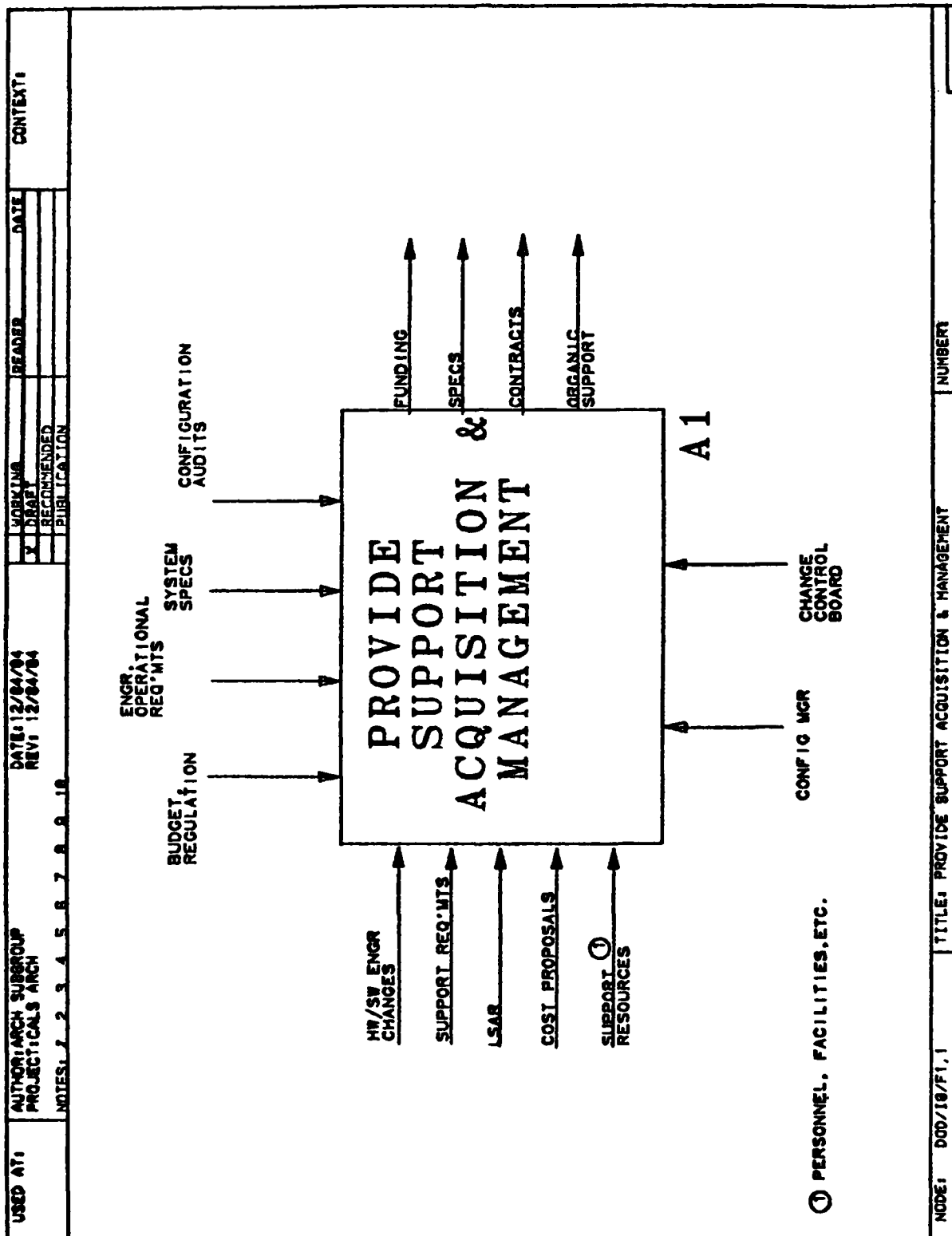


Figure 2-29. IDEF A1, PROVIDE SUPPORT ACQUISITION MANAGEMENT, DOD

Table 2-20. IDEF A1, SUMMARY

A1 Provide Support Acquisition and Management

Glossary

System Specs - The top level documents which define the system's requirements.

Hardware Software Engrg Changes - Changes to the design of the hardware or software resulting from test, reevaluation, or other requirements.

Config. Mgr. - The individual responsible to manage and control the hardware/software configuration and its documentation relationship.

Contractor - The organization responsible for performing to the contract.

Engineering/Operational Requirements - The specified performance requirements and operational scenarios including maintenance scenarios from which to tailor the support resource acquisition.

Change Control Boards - A committee of persons from affected Departments who review and judge the need for design changes; considering: cost and schedule impact, change necessity, effectivity, configuration concerns, design and performance impact, and other matters.

Config. Audits -

Funding/Contract - The money and contract made available to acquire the support resources.

Accurate Config. Data - Configuration management data which accurately portrays the updated configuration of a material item.

Support Requirements - The Government (user) approved maintenance planning.

Support Resource - An item or person required to perform maintenance as provided from the maintenance planning process.

Ready the Systems - On date at which all maintenance resources are in place and the user organization self sufficient for maintenance.

Logistics Acquisition Manager - The person responsible to obtain the approval logistic resources for the Government.

LSAR - Logistic Support Analysis Record documenting the results of analyses from which the maintenance concept and support resource requirements are derived.

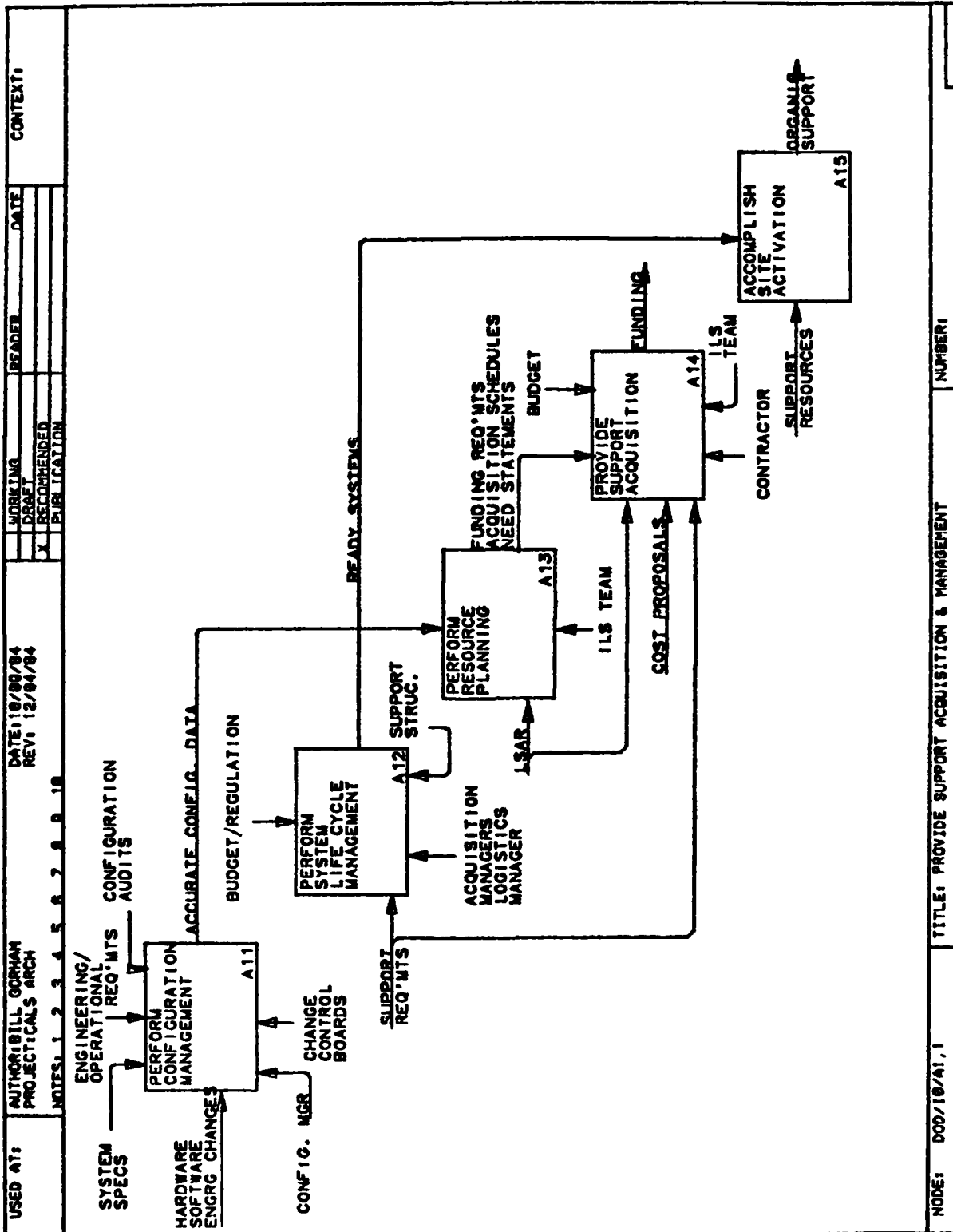


Figure 2-30. IDEF A1n, PROVIDE SUPPORT ACQUISITION MANAGEMENT, DOD



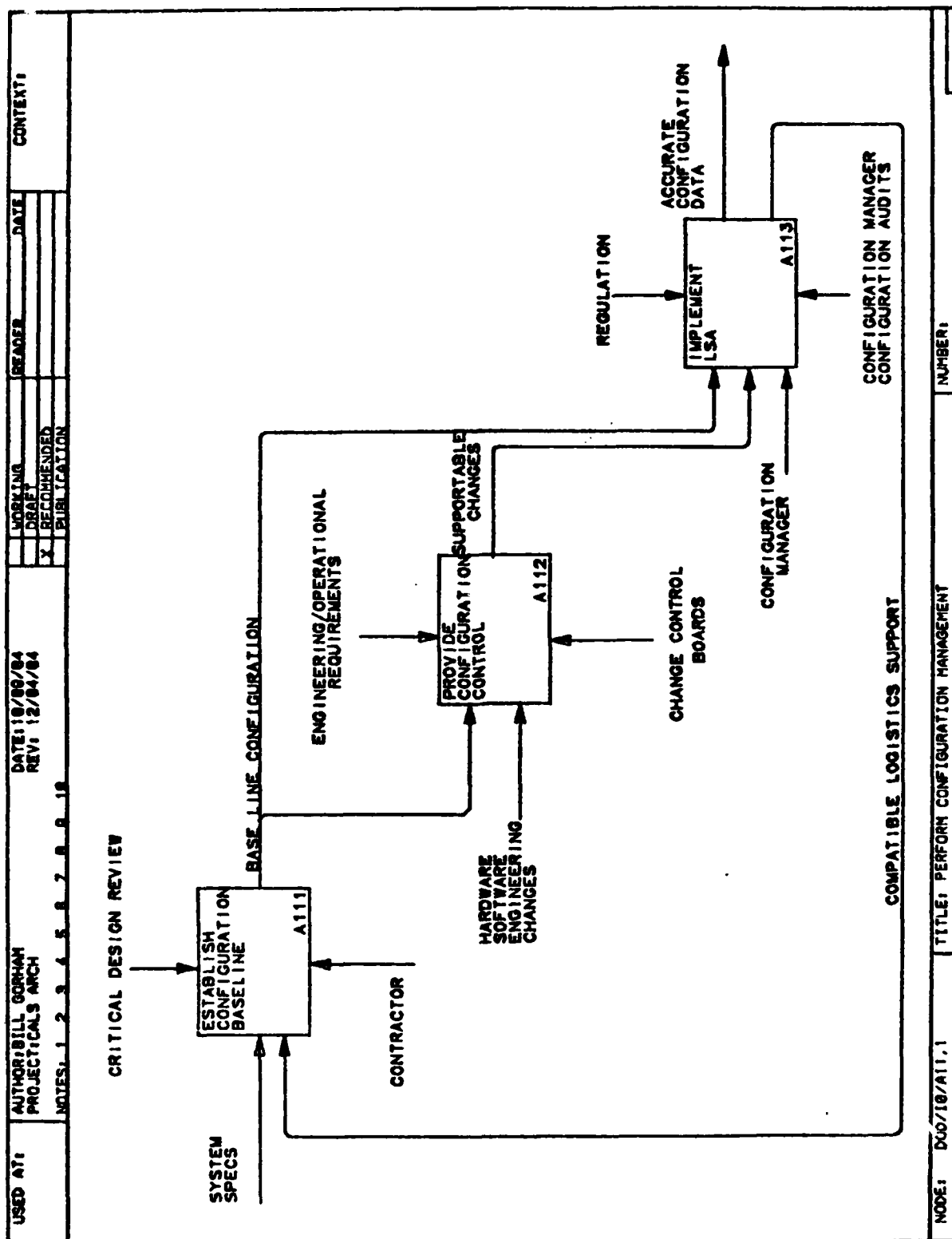


Figure 2-31. IDEF A11n, PERFORM CONFIGURATION MANAGEMENT, DOD

Table 2-21. IDEF Alln, SUMMARY

Alln Perform Configuration Management

Glossary

System Specs - The top level documents which define the system's requirements.

Contractor - The organization responsible for performing to the contract.

Hardware Software Engineering Changes - Changes to the design of the hardware or software resulting from test, reevaluation, or other requirements.

Base Line Configuration - The configuration of the hardware and software established and documented at a particular period of time.

Engineering/Operational Requirements - The specified performance requirements and operational scenarios including maintenance scenarios from which to tailor the support resource acquisition.

Support Changes - Changes in support planning or support resources tailored to equipment changes.

Change Control Boards - A committee of persons from affected Departments who review and judge the need for design changes; considering: cost and schedule impact, change necessity, effectivity, configuration concerns, design and performance impact, and other matters.

Configuration Manager - The individual responsible to manage and control the hardware/software configuration and its documentation relationship.

Compatible Logistics Support - Logistic support adjusted to address the specified configuration of the system/equipment being supported.

Configuration Audits -

Accurate Configuration Data - Configuration management data which accurately portrays the updated configuration of a material item.

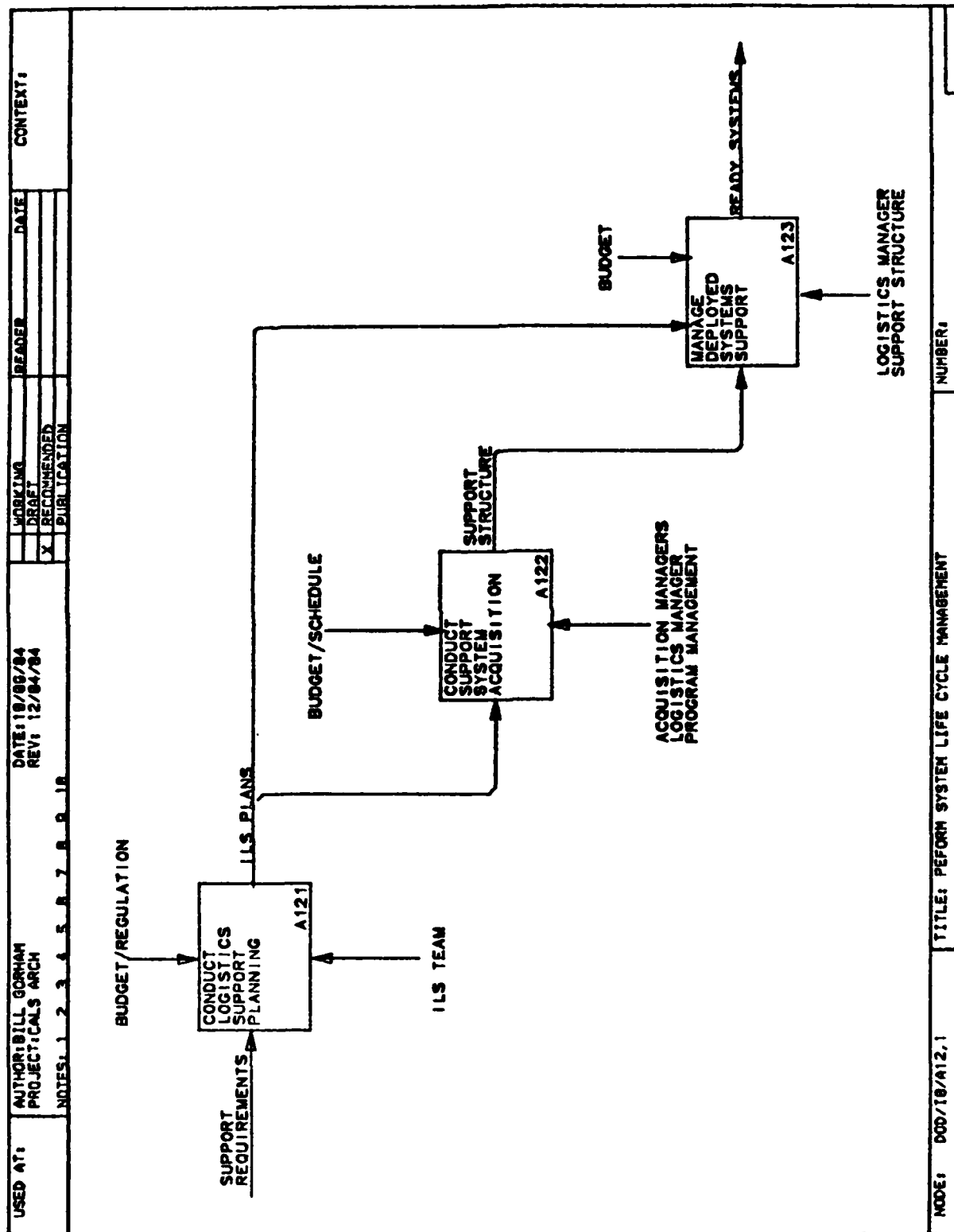


Figure 2-32. IDEF A12n, PERFORM SYSTEM LIFE CYCLE MANAGEMENT, DOD

**A12n Perform System Life Cycle Management**

**Glossary**

**Support Requirements** - The Government (user) approved maintenance planning.

**ILS Plans** - Documents which define the approach for Integrated Logistics Support (ILS) on a program; including schedule, milestones, activities, responsibilities, interfaces with other portions of the program, etc.

**Contractor** - The organization responsible for performing to the contract.

**Budget/Regulations** - Constraints placed on the acquisition manager in the acquisition and maintenance of support resources.

**Support Structure** - The maintenance concept upon which the support planning is based. It determines the maintenance levels and resources at each level.

**Acquisition Managers, Logistics Manager, Program Management** - The manager responsible for support resource acquisition, support planning and support requirements development.

**Ready the Systems** - On date at which all maintenance resources are in place and the user organization self sufficient for maintenance.

**IDEF A1 DESCRIPTION**  
**CALS FOR SUPPORT ACQUISITION AND MANAGEMENT**

o **CURRENT STATUS**

- Primarily hard copy
  - Inputs
  - Controls
  - Outputs

o **TARGET SYSTEM CHARACTERISTICS**

- Automated (soft copy)
  - Inputs
  - Outputs
  - Controls
- Automated resource management

o **BENEFITS**

- More efficient and cost-effective management of resources
- Expedites planning, acquisition, and management process
- More cost-effective utilization of corporate experience resident in data base
- Faster adjustment of acquisition strategies in response to changing requirements
- Immediate availability of configuration change control data enhances data system currency
- Continuously updated configuration status accounting information
- Rapid response of logistics support system to configuration changes

o **PROBLEMS**

- Compatibility of contractor and Government data systems
- Availability and compatibility of contractor data
- Proliferation of high capacity PCs promotes creation and utilization of individualized unique systems exacerbating the centralized control and coordination problem

o **IMPLEMENTATION APPROACH**

- Standardize specification imposed by Services on contractors for automation of deliverable technical data
- Services established own automation capabilities to utilize and mesh with contractors automation systems
- Establish DOD oversight of Service activities in these areas and provide specific DOD direction
- Provide adequate funding

o **IMPLEMENTATION COST**

- The approach is too MACRO at this point for any kind of useful cost estimate.

## IDEF A1 CONCEPT PAPER

### CALS FOR SUPPORT ACQUISITION AND MANAGEMENT

#### 1. FOCUS OF CALS IMPLEMENTATION

1.1 Overview. The concept of using Computer-Aided Logistics Support (CALS) to improve System Support Acquisition and Management requires:

a. Positive management actions to integrate all logistics elements within a program in order to optimize the availability of resources and to minimize support costs,

b. A systematic management approach to the early integration of support criteria into design activities, and

c. A credible technical basis for developing and/or improving Life Cycle Cost estimates within the performance and availability requirements of the program.

The advancements in computer and communication technology provide vast opportunities for logistics managers to introduce new methodologies into logistics management techniques. The trend toward distributive processing--the use of small, specialized computers tied together to reduce or eliminate the need for large data bases--will result in an increased requirement for high-speed communications circuits within and between the various levels of logistics support. The trend toward higher data exchange volumes can be expected to continue to increase as Government computer operations move from large-scale computers and batch processing to smaller computers and on-line distributive processing.

1.2 Implementation Considerations. Considerations of CALS in System Support Acquisition and Life Cycle Management should include the following:

- a. Complete and up-to-date information essential to life-cycle support of a system/program,
- b. Access to this information for concerned parties from various geographical locations, and
- c. Data base access and control of data base integrity.

The configuration of a logistics support information processing network with a series of "hub" computers and satellite terminals laid out in pyramid fashion would provide vertical as well as horizontal access to all of the data. At the lowest level, each of the logistics element managers would be a "hub" for information relating to a particular element (e.g., spares, technical data, training, etc.) for a specific program. At the next higher level, each logistics program manager would be a "hub" for information on all logistics elements, as well as on other related functions (e.g., configuration management, engineering, data management, etc.) for a specific program. The next higher level would have a logistics systems manager who would be a "hub" for all logistics program managers. Other levels of management could be interspersed in order to provide a greater degree of control; however, functions and capabilities would remain essentially the same. Each "hub" would have access to various data bases, with the "hub" manager being able to change the information in a particular data base as required by its particular level. The manager would have query capability only for those data bases provided by lateral and subordinate activities; however, he would be able to access, input, and revise those data bases which provide information to lateral and superior activities.

**1.3 Payoffs and Benefits.** There are several immediate benefits which can be derived from having complete and up-to-date information on all aspects of a system's support structure in a central location which is accessible to all parties with legitimate needs. These benefits are listed below.



- a. Expedites access to maintenance, spares, and configuration information.
- b. Provides centralized control of system diagnostics, technical orders, and hardware/software changes.
- c. Provides users interactive training programs.
- d. Provides a ready source of baseline equipment from the numerous computers in current use.

The prioritized needs of the total set of on-site and remote users will determine how intelligent and how powerful the remote terminals must be in relation to the console terminals co-located with the host facility. Access to the central facility involves both retrieving/refreshing information resident in the data banks and using the central processing unit in the large host computer.

**1.4 Changes Needed and Anticipated Problems.** Of the changes needed and problems anticipated in establishing a logistics support information processing network for logistics management support, user priority is one of the most important considerations. The question of user priority must be addressed in defining the hierarchical structure of information processing.

The necessity for a common communications interface and command language is obvious and should be addressed early in the network planning process. A properly researched statement of requirements and adoption of a particular communications protocol can have a synergistic effect upon a distributed data processing (DDP) network, thereby eliminating protocol conversion and retrofit. Such adoption may narrow the field of vendors but also may have the positive impact of preventing computer manufacturers and network users from committing themselves to unique and incompatible protocols.

The Department of Defense is moving toward standardization with MIL-STD-1777, Internet Protocol Standard, and MIL-STD-1778, Transmission Control Protocol Standard, which were adopted by the

Air Force on 1 March 1983. To further direct standardization efforts, the Department of Defense has entered into a cooperative venture with the National Bureau of Standards.

## **2. CANDIDATE FUNCTIONS FOR CALS**

There is no single logistics element or related function which would not be a candidate for automation, standardization, and integration into a hierarchical CALS information processing network.

**2.1 Technical and Maintenance Data.** One interesting CALS application will be to place technical and maintenance manuals on videodisc/videotape. On a videodisc, for instance, 10 seconds of audio could accompany one frame of video, making possible a talking maintenance manual providing 27,000 full-color, still-frame pictures and 75 hours of audio commentary on one disc. A relatively cheap microcomputer can control the videodisc player with an inexpensive, commercially available interface. The ability of this system to access frames randomly and run still, slow, or full motion is well suited to locally programmable training, briefing, and maintenance applications. The video and audio presentations can then be saved on a videotape for further distribution. Spare parts listings and ordering information currently on microfiche can be transferred to videodisc, allowing use of the videodisc hardware for many purposes.

**2.2 Support Acquisition Data.** Support acquisition using this information network will benefit from more accurately predicting the requirements for spares and repair parts. It will permit better production planning and justify setting aside industrial facilities to make spares for systems. This, in turn, will permit the Government to get better prices and shorter leadtimes from industry when it can be shown that paying inventory carrying costs to shorten leadtime and letting multiyear contracts to reduce the unit price can be justified by the utilization rate.

Information on the utilization rate will be readily available for any system/equipment, along with other information such as the technical specification, cost and schedule information, and the results of level of repair (LOR) and logistics support analyses.

**2.3 Configuration Management Data.** In the area of configuration management, this information network can be used to provide the configuration status of each piece of equipment by serial number, type, and model. All reference designators, such as drawing number, revision, and modification identification, also will be entered. Then, as a modification or retrofit is made to an equipment, the information will be entered into the system identifying the type of modification. Anyone with access to the system will then be able to determine which equipment has what modifications. This will ensure system compatibility when a piece of equipment is replaced, permit accurate configuration status accounting, and allow managers to make better utilization of limited resources.

**2.4 Resource Planning Data.** Resource planning will be easier and faster using this information network, no matter what stage of the acquisition cycle is involved. It will not make much difference whether it is to provide for site activation, system maintenance, round-the-clock operation, or phasing out an equipment; having all of the related information available when and where it is needed will be a tremendous improvement over the current paperwork and manpower-heavy manual systems. Managers will seek information not by word of mouth but rather through pictures (computer graphics). Computer graphics systems will allow a machine to do much of the data aggregation, synthesis, and presentation which is currently being performed manually.

Some of the problems of information overload, perishable data, and cost of production of presentations may be mitigated by the current technology of computer graphics. The two most basic benefits of computer graphics will be in saving the manager's

time and in helping managers make better decisions. Computer graphics can save the manager's time by simplifying the interpretation of data and by facilitating the communications of complex findings. Computer graphics help managers make better decisions by allowing them to: (1) scan and digest more information, (2) detect trends or deviations more readily, and (3) rapidly generate many different presentations.

### 3. ANTICIPATED RECOMMENDATIONS

3.1 Funding Issues. Successful Government ILS planning during all phases of the equipment life cycle requires management attention to the interface between the support element needs and defense budgeting and financing procedures. Typical budgeting and financing activities will include:

- a. Early determination of logistics support funding requirements which, together with experience factors obtained from similar equipment programs, permit accurate forecasting of Life Cycle Costs;
- b. Accurate updating of forecasts for timely fiscal planning and apportionment of required research and development, investment and operating funds; and
- c. Accurate accounting of funds expenditures using work breakdown structure and measurement criteria to ensure proper funds utilization and redistribution.

There are several alternatives to consider when addressing funding for developing the concept of using Computer-Aided Logistics Support (CALS) to improve System Support Acquisition and Management. They range from total Government-sponsored development of potential CALS applications to providing incentives to industry to develop CALS techniques and procedures. A good starting point might be for the Government to provide matching funds to industry to encourage development of fully automated procedures. However it is done, the first phase

should include a formal feasibility study to determine the constraints and limitations that CALS would operate within.

**3.2 Incentive Issues.** In order to accelerate the development of automated Support Acquisition and Management processes, the Government must provide the necessary incentives to industry. Incentive issues should address funding for all support studies, exploratory development of support items requiring state-of-the-art advancement, and include the proposed allocation of concept formulation fund requirements.

**3.3 Contracting Issues.** The major contracting issues to be addressed will result from the use of obligatory, standard computerized Support Acquisition and Management techniques which will impact contractual regulations. The Government should be able to gain the necessary competitive leverage with the potential contracting sources by invoking a requirement for automated Support Acquisition and Management procedures in certain specific Requests for Proposal (RFP). Although there are other methods, this would probably be the most cost-effective way to provide the necessary incentive for contractors to adopt CALS techniques. It should also be the most direct and timely alternative for the Government to employ in order to obtain CALS to improve System Support Acquisition and Management techniques.

**3.4 Specification and Standards Issues.** Standardization and specification issues are critical items which must be addressed at the outset in order to prevent a proliferation of independent, stand alone models, a condition which would inhibit, if not prevent, interoperability among potential users. One way to ensure compatibility would be to retain the manual methods of providing for System Support Acquisition and Management while transitioning to CALS. This will permit existing specification

and standards to be modified/adjusted concurrently with the preliminary development of automated programs. This also will allow the Government to obtain the maximum utilization out of the numerous "personal computers" already in use, while transitioning into the final networking of computers.

**3.5 Technological Changes.** The projected technological advances in computer technology, data management and exchange techniques, and communications methods should encourage the rapid introduction of an automated concept for Government and industry alike within the very near future.

**3.6 System Characteristics.** In defining system characteristics, areas such as data security, data integrity, and proprietary data rights must all be given high priority. The need for access to the information contained on the system by concerned parties from various geographical locations must be weighed against the need to control access to the system. The requirement for constant updates and/or reviews of the data base must be balanced by the concern for data loss and unauthorized manipulation. Finally, the need to respect proprietary data rights and techniques must not interfere with the Government's right to obtain the basic data necessary to develop/expand CALS.

**3.7 Policy Issues.** Governmental invocation of contractual obligation by industry to comply with approved standards for system development is now an accepted provision of DoD policy. Therefore, requiring industry to implement standard computerized Support Acquisition and Management techniques during systems development should not require any significant modification to the DoD systems acquisition policies.

#### 4. CHOICE OF CANDIDATES JUSTIFICATION

4.1 High Payoff. The Support Acquisition and Management candidates for automation will provide the opportunity for substantial cost benefits in terms of

- o Paper reduction,
- o Improved data accuracy, and
- o Improved data availability.

Cost benefits in paper reduction alone will justify the automation of Support Acquisition and Management of systems. In addition to the savings in reduction/elimination of reports, plans, etc., there is the potential of tremendous savings in the filing and storage of paper documents.

4.2 Feasibility. The concept of fully automated techniques for Support Acquisition and Management procedures is well within the realm of functional feasibility, given the present state-of-the-art electronic data processing technologies. The proliferation of decentralized, nonstandard, and relatively inexpensive computer aids will quickly lead to development and implementation of automated Support Acquisition and Management procedures by industry as well as by Government. The Government must get the jump on this rapidly expanding phenomenon to take full advantage of its vast potential for improved product quality and decreased acquisition leadtimes and associated costs.

## CALS FUNCTIONAL DESCRIPTIONS

### DoD FUNCTIONS:

#### 3. IDEF A2, CALS for Training



USED AT:	AUTHOR/ARCH SUBGROUP PROJECT/CALS ARCH	DATE: 12/04/84 REV: 1	WORKING Y	READER	DATE	CONTEXT:
NOTES: 1 2 3 4 5 6 7 8 9 10			DRAFT			
			RECOMMENDED			
			PUBLICATION			

**COST, SCHEDULE, REQ'TS**

**TRAINING PLANS & OBJECTIVES**

## PROVIDE TRAINING

A2

↑

TECH SPEC.

↑

MAINT. PLAN

↑

INSTR. SYS  
DESIGN REQ'TY

↑

DESIGN DESCR.

↑

LSA DATE

↑

TECH MANUALS  
R.M. ANALYSIS

↓

ORDER

↓

TEST RESULTS

↓

EVAL MAT'L

MODE: DOD/18/F2.1	TITLE: PROVIDE TRAINING	NUMBER:
-------------------	-------------------------	---------

Figure 2-33. IDEF A2, PROVIDE TRAINING, DOD

## A2 Provide Training

Three activities are used to describe the framework for training. The first activity is the definition and acquisition of training equipment. Training equipment is presently defined by individuals knowledgeable in the methodologies of training for the system in question, and in the results required. They would develop a plan, determining hardware, software, and procedures; issue purchase requisitions, specification and design requirements; and make the appropriate arrangements to acquire all training materials.

The next activity is the development of courses. A System's training course is now planned and written after the design is completed, and usually after the hardware is built. Actual hardware is used to help design the course by running it through its paces and introducing faults and simulated situations. Courses are now developed for either computer-based training, human interaction, or simulation techniques using actual hardware.

The last activity is the actual conducting of training. Computer-based instruction, equipment simulation, and classroom and field training on actual equipment are all presently used.

Innovations which will affect training will occur in computer, video and training technologies. Computer-related advancements which will impact training include: improved user interfaces, cheap memory, multi-tasking machines, powerful handhelds, and reasonably costed 3-D color graphics systems.

Training technologies will advance to take advantage of delivery media improvements. Artificial intelligence (AI) concepts will be directly or indirectly applied to training. That is, where feasible, we will use expert training systems to provide instruction and assistance to operators and maintenance personnel.

### Glossary

**Cost, Schedule, Requirements** - Cost and Schedule restrictions are provided by the contract Statement of Work. On-the-job (OJT) training for persons not familiar with the equipment could allow performance of a task by using built-in computer aids. Defined by the contract Statement of Work as to the type of training required on the program. It could be formal, classroom training, on-the-job (OJT) training, or other types.

**Technical Specification** - That document provided as part of the contract which defines the operational, design and performance requirements of the system.

**Maintenance Plan** - Equipment Specification and/or Maintenance Scenario Analyses at a higher level.

**Instruction System** - Maintenance training, operator training, and general basic training as defined by design requirements.

Table 2-23. IDEF A2, SUMMARY, DOD (sheet 2 of 2)

**A2 Glossary (Con't)**

**Design Description** - Results of the design program; including drawings, analysis, schematics, test results.

**Order** - The process and data used to order material and services.

**Training Material** - Data used to conduct the training other than the courseware (description of trainers, mock-up, etc).

**Training Aids Requirements** - The use of the training devices and how to integrate them into the overall training program.

**LSA data** - Logistics Support Analysis data.

**Technical Manuals** - As provided by Reliability and Maintainability design analysis.

**Develop Material Testing** - The material used to evaluate the student's performance and the extent of learning; also the material used to evaluate the course content and presentation.

**Courseware, Guides, Procedures** - Computer-generated design tools and outlines generated by the design process.

**Training Plans and Objectives** - The achievement of built-in-training which provides for on-site field training for equipment use and maintenance.

**Test Results** - The results of testing the student in the course material.

**Evaluation Material** - The results of the students evaluation of the course, including recommendations for changes and improvement.

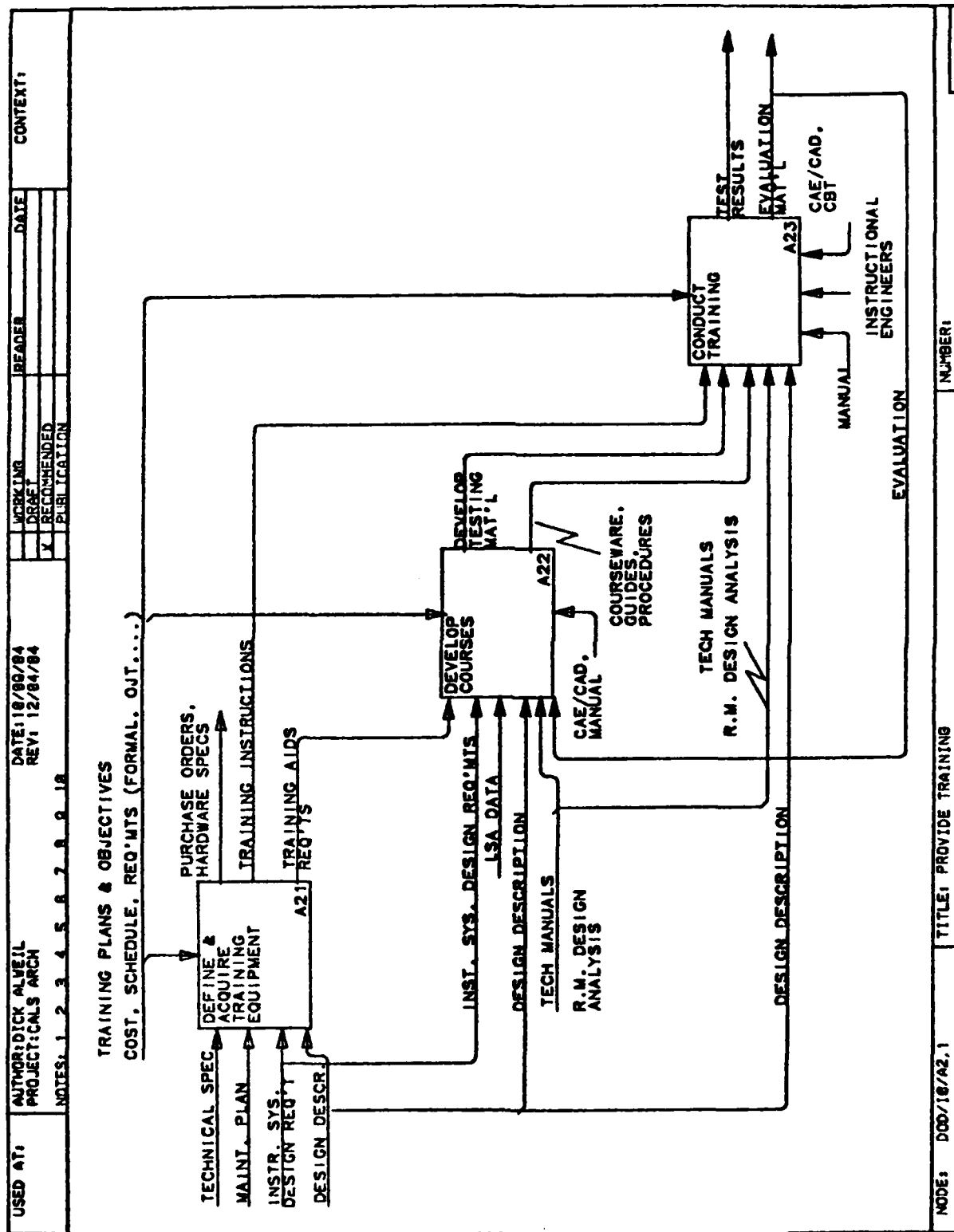


Figure 2-34. IDEF A2n, PROVIDE TRAINING, DOD

## CALS FUNCTIONAL DESCRIPTIONS

### DoD FUNCTIONS:

#### 4. IDEF A3, CALS for Maintenance

USED AT:	AUTHOR: ARCH SUBGROUP PROJECT: CALS ARCH	DATE: 12/84/84 REV: 10	RENDER		DATE	CONTENT:
			WORKING X DRAFT RECOMMENDED PUBLICATION			
NOTES: 1 2 3 4 5 6 7 8 9 10						

OPERATIONAL  
FAILURES

REQ'D REPAIRS

DESIGN DESCRIP.

BIT IND

I.O. PROCEDURES

ENGR DATA

ONE-CONDITION  
RECORDING

## PERFORM MAINTENANCE

SUPPLY DEMAND

STATUS

DEFICIENCY  
REPORTS

OPERATIONAL  
REQ'MTS

INSPECTION  
& OVERHAUL  
REQ'MTS

REPAIR OR  
CANNIBALIZE  
DECISION

POLICY  
& DATA  
SYSTEM  
DESIGN

A3

NODE: DOD/18/F3,1	TITLE: PERFORM MAINTENANCE	NUMBER:
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Figure 2-35. IDEF A3, PERFORM MAINTENANCE, DOD

A3 Perform Maintenance

Glossary

Operational Requirements - Planned utilization of the system being supported.

Trends - Feedback from failure analyses to determine patterns of failure.

Inspection & Overhaul Requirements - Planned cycles of maintenance and activities therein.

Operational Failures - The failure of an item to meet its intended operational requirement/function.

Schedule/Order - Written instruction and authority to perform a maintenance task including the time phasing.

Job Order - Detailed work statement with which to execute the maintenance action.

Resource & Equipment Status - Inspection report defining the items serviceable status or repair requirements.

Required Repairs - Repairs needed to return an item of material to operational/serviceable condition.

Design Description - Design information such as drawings or performance specification.

Supply Demand - Requisition for replacement items.

Repair or Cannibalize - Decision to fix an unserviceable item or use a serviceable part from another larger component or end item as a substitute for the unserviceable part.

Status - Reported condition.

BIT Ind - Built-In-Test indication.

T.O. Procedures - Maintenance procedures prescribed in a technical order.

Engineering Data - Data and analysis developed during the design and test phases of the program.

Maintenance Action Data - Report delineating the maintenance action, resources required, task times etc, utilized to effect a repair.

Policy & Data System Design - Maintenance Policy and Maintenance Data relating to the design of the system under maintenance.

Deficiency Reports -

Table 2-24. IDEF A3, SUMMARY, DOD (sheet 2 of 2)

A3 Glossary (Con't)

On-Condition Recording -

T.O. Procedure, Physical/Functional Design Description -

T.O. Procedures, Design Description -



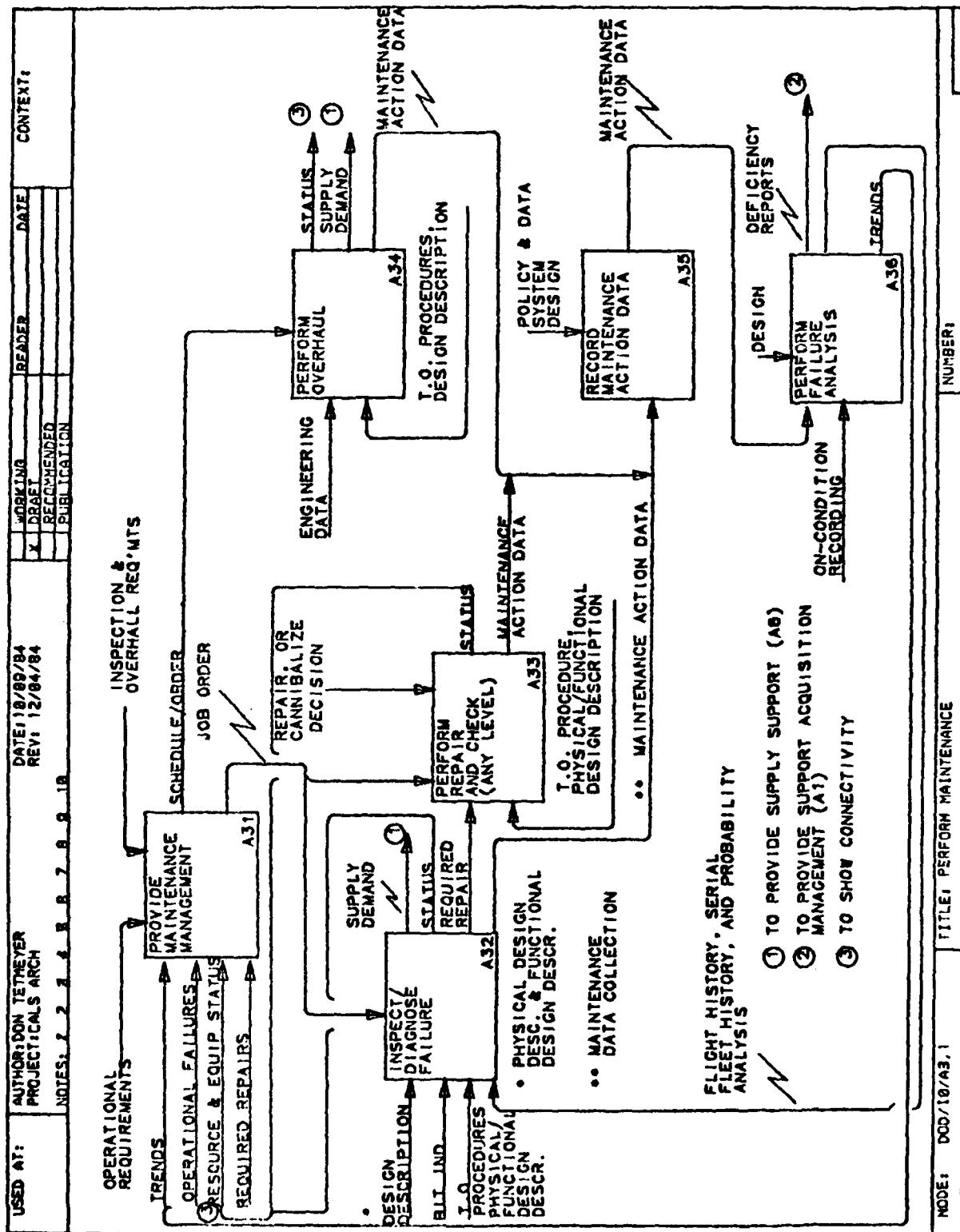


Figure 2-36. IDEF A3n, PERFORM MAINTENANCE, DOD

## IDEF A3 CONCEPT PAPER

### CALS FOR MAINTENANCE

#### 1. FOCUS ON CALS IMPLEMENTATION

1.1 Overview. Battle 2000 concepts envision high mobility, battle on the run, the possibility of chemical or biological warfare, coupled with limited quantities and unpredictable locations of forward bases, support resources and trained personnel. The conditions under which maintenance must be performed will consequently be so severe that neither conventional maintenance instructions nor maintenance resources will suffice.

Technicians will be required to perform repairs with little or no training for the particular task. In addition, the next generation of weapon systems will feature extensive use of micro electronics in avionics, control systems, and built-in sensing and monitoring of equipment condition. Even mechanical systems (such as aircraft flight control surfaces) will be configured by computers as necessary. The architecture of these self-programming systems will involve basic components (e.g., power supply) that are automatically reconfigured into different subsystems as needed, to perform multiple functions during a mission, and to work around failed components. A new maintenance decision is added: whether to fix such a system or let it continue to operate and degrade. Maintenance will be more complex (fewer packaged "big black boxes" to pull) and require software as well as hardware maintenance. Component reliability will be much higher and more uniformly distributed, which leads to a paradox in that fault isolation becomes less reliable, because when reliability of sensor and sensed are similar it is more difficult to have confidence in failure location.

Battle damage which by its very unpredictability and multiple simultaneous faults is not normally accurately assessed or located by Built-In-Test programs must be properly diagnosed, corrected, or otherwise dispositioned. Computerized maintenance

aids will provide for effective maintenance under these austere circumstances, resulting in quicker maintenance turn-around, and higher confidence in successful repair than otherwise possible.

### **1.2 Projected Performance of the Target Computerized Functions.**

Assuming that the weapon system is designed to include the appropriate supportability design attributes discussed under "CALS Interaction with Equipment Design/Modification" it remains to provide maintenance aids beyond those contained in the weapon system, as determined and optimized by integrated diagnostics analyses. There are three distinct elements involved in providing automated aids:

a. An authoring system used by the contractor (and perhaps the Service) to create and update the information in appropriate format, as well as provide adequate configuration and quality control.

b. A storage and distribution system used by the Service to accept the information from the authoring system, store, practice configuration control, and reproduce/transmit it for the user.

c. A user's display system to access needed data (and record/feedback for transmission back up the chain).

The title "aids" rather than "instructions" is used for this section to emphasize that future electronic systems need not be bound by these constraints.

### **1.3 Implementation Considerations.**

The maintenance aids system is envisioned to consist of a small portable terminal with which the technician can access maintenance information in an interactive fashion for any type of repair task or battle damage assessment.

Several different approaches to a display system are currently being pursued in Service R&D programs. These include

live photographic action on video disc, multi-level procedures with pertinent line drawings stored in portable digital electronic displays, diagnostic logic models, and artificial intelligence software that operates from the engineering data base. The type of authoring and communication needed will depend in part on the display approach. More research, experimentation, and field trial experience is needed to find out what form of displays are best for specific situations. For example, there is evidence that simple line drawings that extract and highlight the key information are more effective than full fidelity photographic pictures for illustrating maintenance sequences. However, this might not hold true for initial training on equipment location.

For the near future there will likely be several different approaches tried in the three Services. Eventually these will evolve into a system in which the contractor uses CAD-type technology and artificial intelligence aids for efficient technical data authoring, quality control, and configuration management. The authoring software must facilitate the integration and process control of information drawn from the engineering data base and prepared by different writers. The Services will establish standards for electronic receipt of these data, a standard data base manager to store, update and control the resident data, and standards and new communication capability to transmit large volumes of new data and updates to the field. This could be by satellite data links. At some central field locations the data update transmissions will be converted to the appropriate storage from (e.g., hard disc, optical disc, etc.) for distribution to the local users. The maintenance technicians or operators will display the data on their transportable or imbedded display computers. These computers will have diagnostic and AI capability, and communication links to available weapon system data bases.

**1.4 Likely Payoffs.** The computer can handle the cross-referencing relationships for rapid, transparent access to all parts of the data base for transmission to the technician's display. This will permit multiple levels of detail and presentation tailored to the skill of the user. The computer can perform functions such as schematic tracing and parts identification and can assist in providing dynamic troubleshooting logic and augment the data base with the result of each new use. The automated aid becomes an interactive assistant rather than a static instruction. The distinction between test equipment, maintenance aids, and training materials disappears. In the future it will be possible to have a single device and inherent software that would perform diagnostics, aiding, or training as needed. In some cases this could even be imbedded in the prime equipment.

The payoff will be properly maintained equipment even in austere conditions, less spares depletion due to drastic reduction in maintenance errors, and potential for work-a-round procedures developed by artificial intelligence systems using up-to-date complete design information residing in a rapidly interrogated data base. These in turn will have the effect of a force multiplier, increasing sortie rates and decreasing life cycle costs.

**1.5 Changes Needed and Problems.** The conditions under which maintenance will be performed will be very severe. Test equipment will be required to be miniaturized and highly mobile. Electronic warfare will restrict and disrupt communications, whereas chemical/biological warfare will put new constraints on man-machine interfaces with information systems. Battle damage repair will require access to more extensive engineering data than normally provided in technical orders. Ideally, an improvised damage repair should be analyzed to determine operating limits, by the same kinds of techniques as used in design analyses.

Any military system must be designed for use in war as its primary objective. This means consideration of resiliency and redundancy against loss of any single element, and the ability to withstand environments such as chemical and electronic warfare, and be operable by technicians in chemical protection gear. The system should be buffered at each element so that any breakdown is not catastrophic. The user's display should be operable independent of transmission from the central storage, which is only used periodically to transmit updates and feedback.

## **2. IDENTIFICATION OF CANDIDATE FUNCTIONS**

**2.1 Maintenance Management.** Automation can be used to make maintenance management much more efficient and effective. Opportunities include the availability of on-condition data from the weapon system, access to historical data banks to detect trends, use of computers to analyze the effectiveness of processes and procedures, tracking of resource status, optimal job sequencing, and positive configuration control of equipment. The interface with the supply system should provide for automatic parts ordering, status determination, and better decisions on cannibalization and transfer to higher maintenance levels. The Air Force has an automated maintenance system prototype in operation at Dover Air Force Base that is a first step toward capitalizing on these automation opportunities.

**2.2 Automated Repair, Servicing, and Maintenance Aids.** Paper-based instructions on how to operate and maintain military systems have been constrained by the paper media to a rigid, fixed format. In order to keep volume and cost down, any single instruction was presented only one way. Troubleshooting instructions were procedural or in a fixed format (e.g., through a fault tree). These had severe problems in that they were generally too narrow to address all possible problems; neither were they sufficiently accurate because they could not address and check cause and effect as thoroughly and accurately as a computer. A computer does not need to "project" the potential

problem. Instead, the computer can analyze a problem at the time it occurs from the design information available to it. Therefore, this type of automatic fault isolation and repair procedure development is highly recommended.

### 3. ANTICIPATED RECOMMENDATIONS

3.1 Automated Display Device. Many of the functional distinctions we have been used to should break down when the integration opportunities of automation and miniaturized electronics are fully exploited. The functions of a test set and an automated technical data display can be performed by the same portable device. When connectors are standardized, the same device may also do go-no-go checks on removed components.

3.2 Automated Diagnostics. Deep-logic artificial intelligence diagnostics will operate off the same engineering data base used for failure modes analysis in design. CALS will need to include mechanisms for keeping these data current and available as a source for artificial intelligence programs used for diagnostics in the field. This will introduce new configuration management responsibilities to control both configuration changes and failure/mode effect changes that feedback from field experience.

3.3 Software Integration. Software integration and configuration control will become a much more significant workload. Not only will more of the weapon system maintenance involve fixes to software, but all the data bases that should be available to the technicians and maintenance management must maintain information and communication capability. An example of the potential set for Air Force maintenance is shown in Figure 2-37. This is a major challenge for CALS in maintenance.

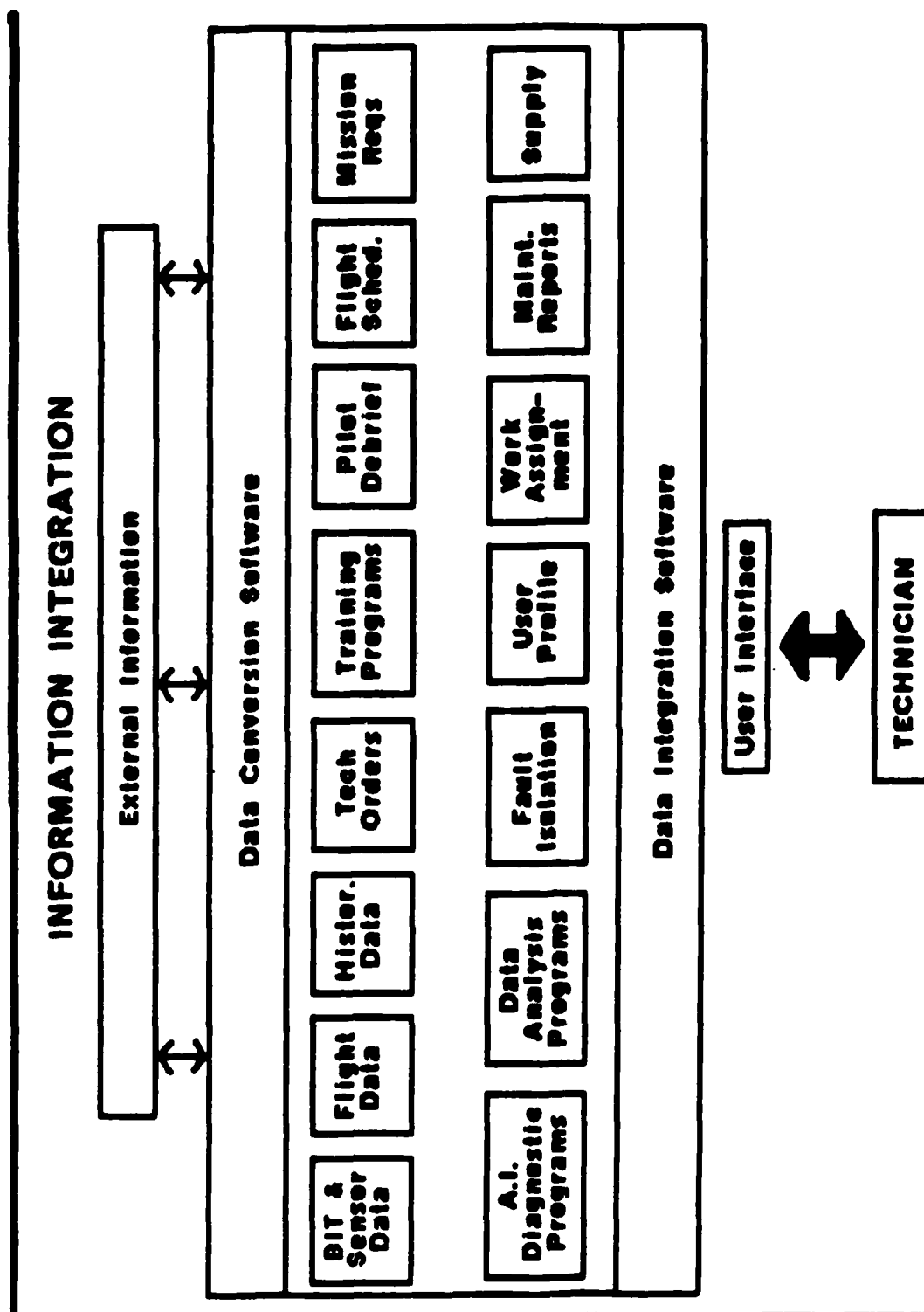


Figure 2-37. MAINTENANCE INFORMATION INTEGRATION



## CALS FUNCTIONAL DESCRIPTIONS

### DoD FUNCTIONS:

#### 5. IDEF A4, Perform Modifications

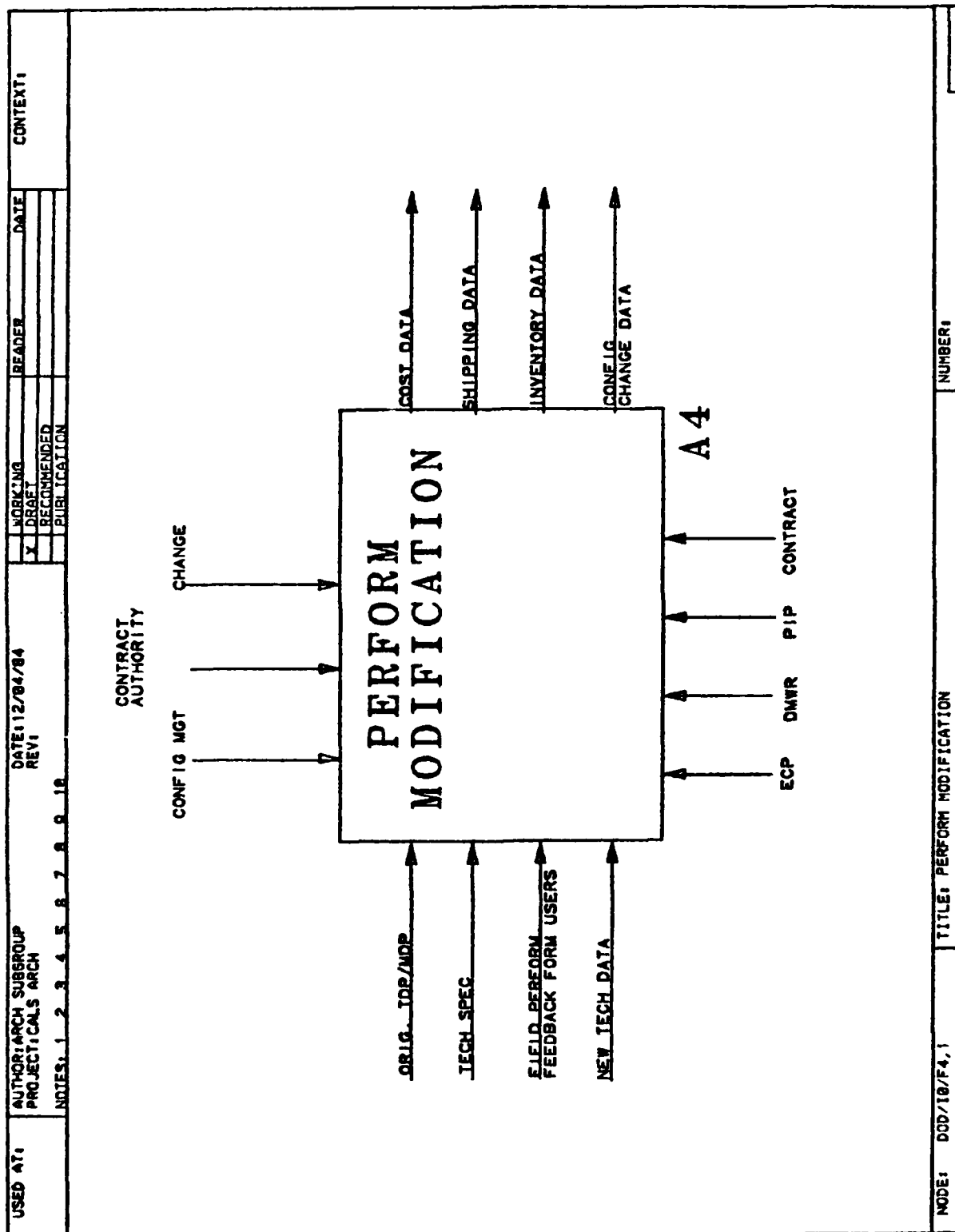


Figure 2-38. IDEF A4, PERFORM MODIFICATION, DOD

A4 Perform Modification

Glossary

Config. Mgmt (TD/CMS) - Technical Data/Configuration Management System a software program which controls configuration and changes thereto.

Orig. TDP/MDP - Tech Data Package/Manufacturing Data Package.

Tech Spec - The technical requirements in the contract.

Redesign Rqmt - An identified need to re-engineer an item based on new technology or reported deficiencies.

Revised Design Data Pkg (TDP/MDP/Manuals) - Data which accompanies equipment to be modified or remanufactured.

Config. Mgmt (CM) - The control of the hardware/software configuration and its relationship to the data package.

Engr Change Proposal (ECP) - Proposal to change the engineering design of equipment, based on new technology or field performance feedback.

Product Improvement Program - Designed to improve performance or enhance reliability and maintainability.

Contract Authority - Procurement office with approval authority to initiate contractual modifications.

Field Performance Feedback From Users - Information from equipment users regarding equipment performance history.

New Tech Data - New technological data available from research labs.

Cost Data - Information on the cost of the item of service.

Shipping Data - Information needed to transport the item.

Inventory Data - Information on material in inventory.

DMWR - Depot Maintenance Workload Requirement - tasking document to the DOD depot for modification/maintenance work to be performed.

Contract - That document under which the Contractor is performing.

Change Authority - Configuration control authority.

Schedule Data - Program data that schedules the application of modifications.

Re-Issue Data - Data resulting from completion of required modifications as equipment is re-issued to the user.

A4 Glossary (Con't)

Configuration Change Data - Information resulting from approved changes to existing configuration.

Modification Work Order (MWO) - Documentation used to initiate the performance of the modification process.

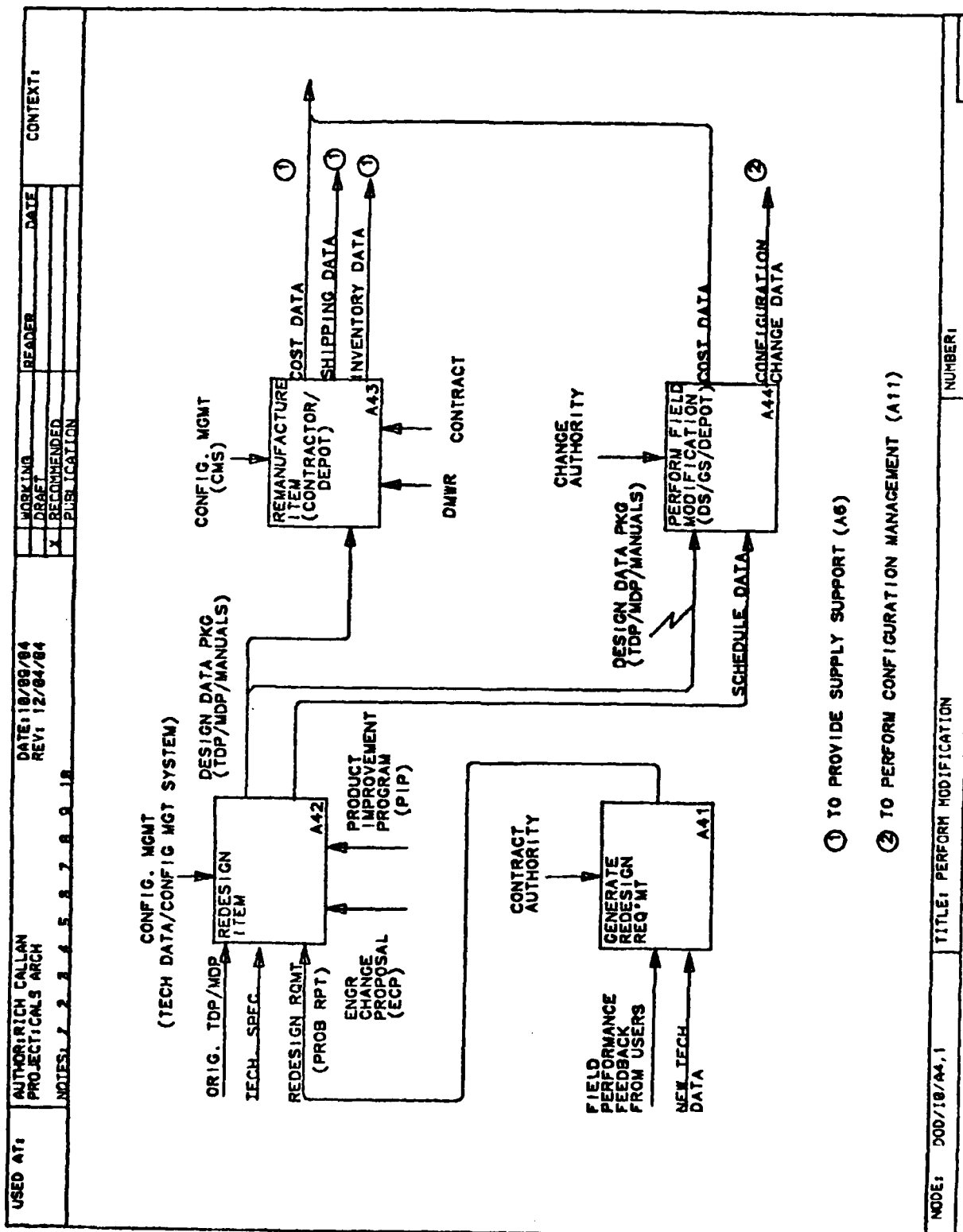


Figure 2-39. IDEF A4n, PERFORM MODIFICATION, DOD

**IDEF A4 DESCRIPTION**  
**PERFORM MODIFICATIONS**

o **CURRENT STATUS**

- Generate Redesign Requirement
  - Field Performance Feedback from users
  - New Technology Data from Equipment Manufactures
- Redesign Item
  - Based on Redesign Requirement
    - Engineering Change Proposal
    - Product Improvement Program
  - Uses technical specification and original technical data/manufacturing data package
- Remanufacture Item
  - Based on Revised Design Data Package
  - Based on Schedule Data
- Perform Field Modification
  - Based on Change Authority
  - Executed via Modification Work Order

o **PRINCIPLES & CHARACTERISTICS OF TARGET SYSTEM**

- Need for automated deficiency reporting systems, tracking systems and management information reports
  - Needed to generate and validate modification requirements
  - Needed to program resources
  - Needed to apply modifications
- Introduce CAD/CAM into modification process
  - Assess DOD needs to develop capability to accept CAD/CAM data electronically from contractors

- Engineering data to be stored digitally on optical disc based storage and retrieval systems

- DOD

- o **BENEFITS**

- Optical-disc based storage systems for engineering data to accelerate the preparation of tech data packages

- Automation of reporting systems:

- Reduce paperwork
  - Provide greater capability to track implementation/application of approval modes
  - Allow better tracking of total weapon system cost

- o **PROBLEMS**

- DOD and Services must determine how to use CAD/CAM data in performing equipment modification

- DOD must define where new applications will be used

- o **IMPLEMENTATION APPROACH**

- Implement optical disc based data system for engineering drawings

- Survey existing Services modification data reporting systems

- Determine where automation provides greatest benefits

- Initial pilot demo to show how Services can standardize procedures or acceptance of digitized CAD/CAM data

- o **IMPLEMENTATION COST**

- Acquisition costs for Services to obtain optical disc based sotrage systems

- Automation of modification reporting systems

- Cost of pilot demonstrations using digitized CAD/CAM data to be quantified.

## CALS FUNCTIONAL DESCRIPTIONS

### DoD FUNCTIONS:

#### 6. IDEF A5, Perform Test and Evaluation



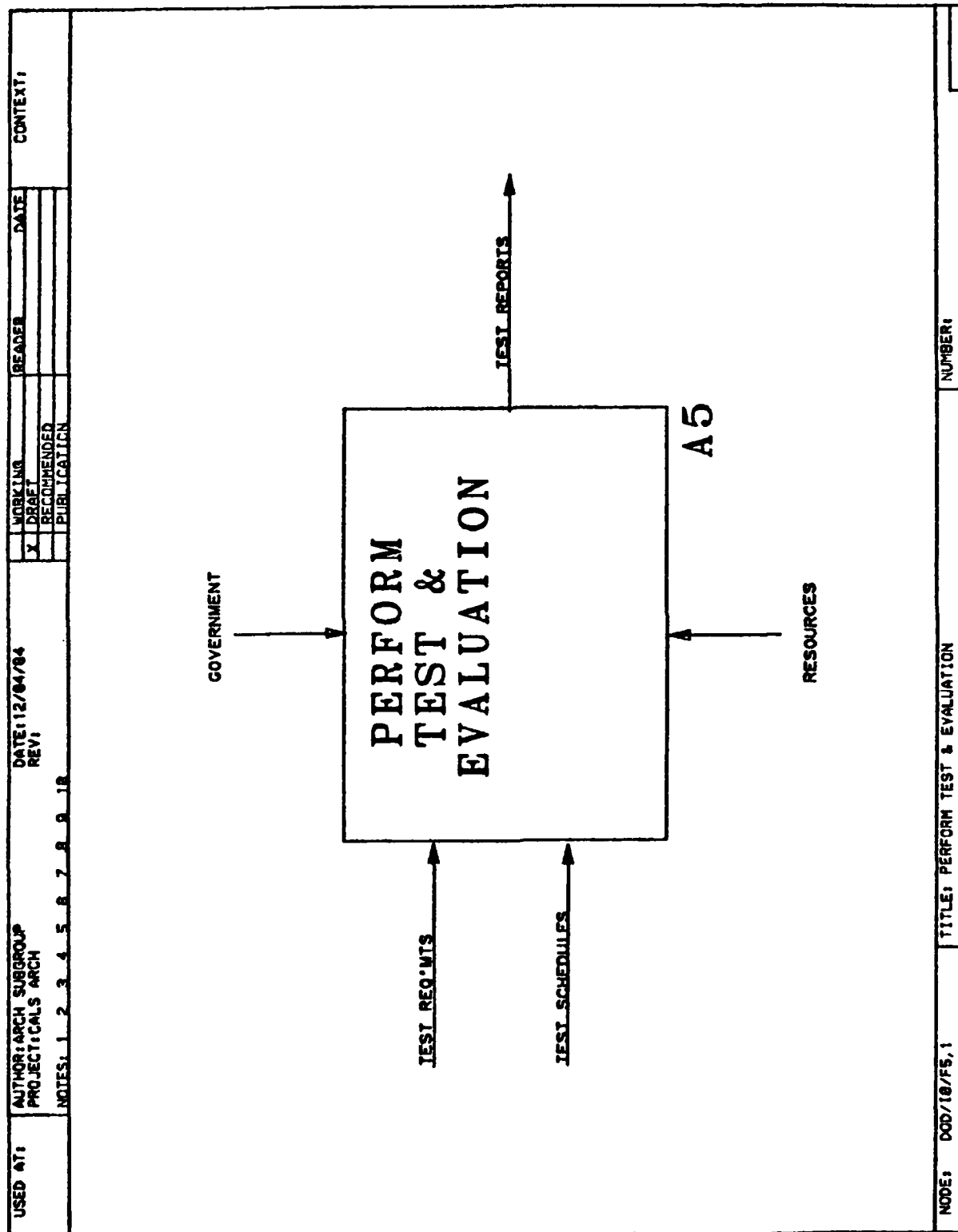


Figure 2-40. IDEF A5, PERFORM TEST AND EVALUATION, DOD

Table 2-26. IDEF A5, SUMMARY, DOD

A5 Perform Test & Evaluation

Glossary

Regulations/Budget - Controlling functions for the performance of test and evaluation.

Personnel - Test personnel.

Resources - That which is needed to perform the testing, including staff, tools, support equipment, facilities, material, budget, etc.

Test Plan/Procedures - The documents which govern the testing program.

Opeval Certification Final Specs - The specified requirements dictating the performance and maintenance parameters to be evaluated during Operational Evaluation.

Test Data/Results - That data which is developed and evaluated during and at the conclusion of the test.

Personnel, Facilities Support, Hardware, Software Funding, Functional Testing, Test Group - The required resources to perform test and evaluation, its planning and the preparation of the report.

Test Reports - The results of the test in report form.

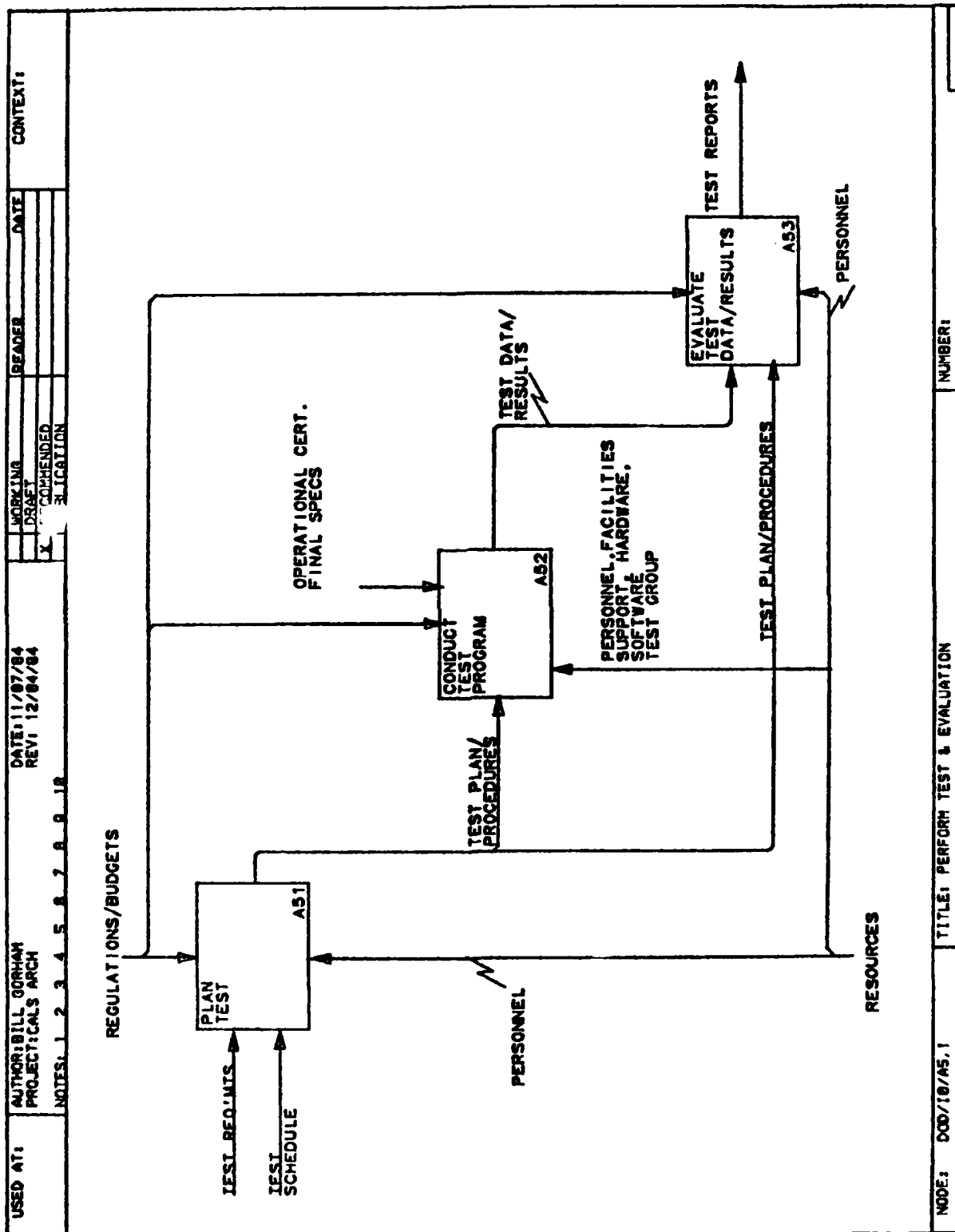


Figure 2-41. IDEF A5n, PERFORM TEST AND EVALUATION, DOD

## **IDEF A5 DESCRIPTION**

### **CALS UTILITY FOR TEST AND EVALUATION, IDEF, DOD**

#### **o CURRENT STATUS**

- Primarily hard copy
  - Inputs
  - Controls
  - Outputs
- Resources management primarily manual

#### **o TARGET SYSTEM CHARACTERISTICS**

- Automated (soft copy)
  - Inputs
  - Outputs
  - Controls
- Automated resource management

#### **o BENEFITS**

- Expedites planning, acquisition, and management process
- More cost-effective utilization of corporate resident in data base
- Faster adjustment of acquisition strategies in response to changing requirements
- Immediate availability of configuration change control data enhances data system currency

#### **o PROBLEMS**

- Compatibility of contractor and Government data systems
- Availability and compatibility of contractor data

- Proliferation of high capacity PCs promotes creation and utilization of individualized unique systems exacerbating the centralized control and coordination problem

- o **IMPLEMENTATION APPROACH**

- Standardize specifications imposed by Services on contractors for automation of deliverable technical data
- Services establish own automation capabilities to utilize and mesh with contractors automation systems
- Establish DOD oversight of Service activities in this area and provide specific DOD direction
- Provide adequate funding

- o **IMPLEMENTATION COST**

- The approach is too MACRO at this point for any kind of useful cost estimate

## IDEF A5 CONCEPT PAPER

### CALS UTILITY FOR TEST AND EVALUATION

#### 1. FOCUS OF CALS IMPLEMENTATION

1.1 Overview. There are two principal types of logistics T&E: Development Test and Evaluation (DT&E), to verify contract technical specification requirements, and Operational Test and Evaluation (OT&E), which evaluates operational effectiveness and Service suitability of new systems and components.

Advanced computer capabilities and networking procedures make possible direct links between Government and contractor test data files. Programs can be written which will assess test data inputs, identifying inconsistencies which forecast developing problems. The program will identify causes and corrective actions. During the analysis, the computer will have all the necessary communication links established for interfacing with the contractor's data bases, thereby integrating all relevant design information for problem solving.

This test capability will be cost effective and will reduce evaluation time. It will assist the Test Director in analyzing problems and measuring their impact on the test program.

This automation capability will be used to evaluate the previously conducted contracted tests using the results to modify the Government test plan to reduce redundancies and highlight questionable areas for priority attention.

1.2 Benefits. Systems engineering risks will be significantly reduced this test emulation which can be used prior to actual test.

1.3 Changes Needed and Anticipated Problems. Standardization to provide software interfaces which will ensure the availability

of compatible global data communications is required so that problems encountered during technical evaluations may be addressed in real time.

## **2. IDENTIFICATION OF CANDIDATE FUNCTIONS**

Computerized system-level simulations will verify the capability of the proposed design to provide the required mission performance to assess risk in testing prior to large expenditures in a test program.

## **3. ANTICIPATED RECOMMENDATIONS**

**3.1 Funding Issues.** In order to successfully adapt CALS to Government T&E, testing requirements must be integrated with budgeting and financing procedures. Methodologies for accurate and early T&E cost forecasting are required and a formal feasibility study of the automation of DT&E/OT&E test procedures should be undertaken as soon as possible.

**3.2 Incentive Issues.** Accelerated development of CALS for T&E requires funding for exploratory development of T&E areas requiring state-of-the-art advancement and for concept formulation efforts.

**3.3 Contracting Issues.** The major contracting issues will result from the use of obligatory standard computerized Support Acquisition and Management techniques which will impact upon contractual regulations. The Government must specify compatible automated Test and Evaluation procedures in Requests for Proposal (RFPs), otherwise the Services will need to tailor their techniques to be compatible with a variety of industries.

**3.4 Specifications and Standards Issues.** Specifications and standards issues must be addressed at the outset to prevent a

proliferation of independent, stand-alone models--a condition which would inhibit, if not prevent, interoperability among potential users. One way to ensure compatibility will be to retain the manual procedures for T&E while transitioning to computer aided techniques. This will permit existing specifications and standards to be modified/adjusted concurrent with the preliminary development of automated programs.

**3.5 Technological Changes.** The projected advances in computer technology, data management and exchange techniques, and communications methods should encourage the rapid introduction of an automated Test and Evaluation support concept for both Government and industry.

**3.6 Policy Issues.** Requiring the services to implement and utilize standard computerized T&E support techniques during systems test phases will require modification to the test procedures and policies.

#### **4. JUSTIFICATION FOR THE CHOICE OF CANDIDATES**

**4.1 High Payoff.** The T&E candidates for automation will provide the opportunity for substantial cost benefits in terms of:

- Paper reduction.
- Improved data accuracy, and
- Improved data availability.

Cost benefits in paper reduction alone will justify automating T&E procedures for systems support. In addition to the savings realized by reducing and/or eliminating reports, plans, etc., a potential exists for significant reduction in the cost of filing and storing paper documents.



4.2 **Feasibility.** The concept of fully automated techniques for T&E procedures is well within the realm of functional feasibility, given the present state-of-the-art electronic data processing technologies. The proliferation of decentralized, nonstandard, and relatively inexpensive computer aids will quickly lead to the Government's ability to develop and implement automated T&E procedures. The Government must respond rapidly to this expanding phenomenon and must take full advantage of its vast potential for improved product quality and decreased acquisition leadtimes and associated costs.

## CALS FUNCTIONAL DESCRIPTIONS

### DoD FUNCTIONS:

#### 7. IDEF A6, Provide Supply Support

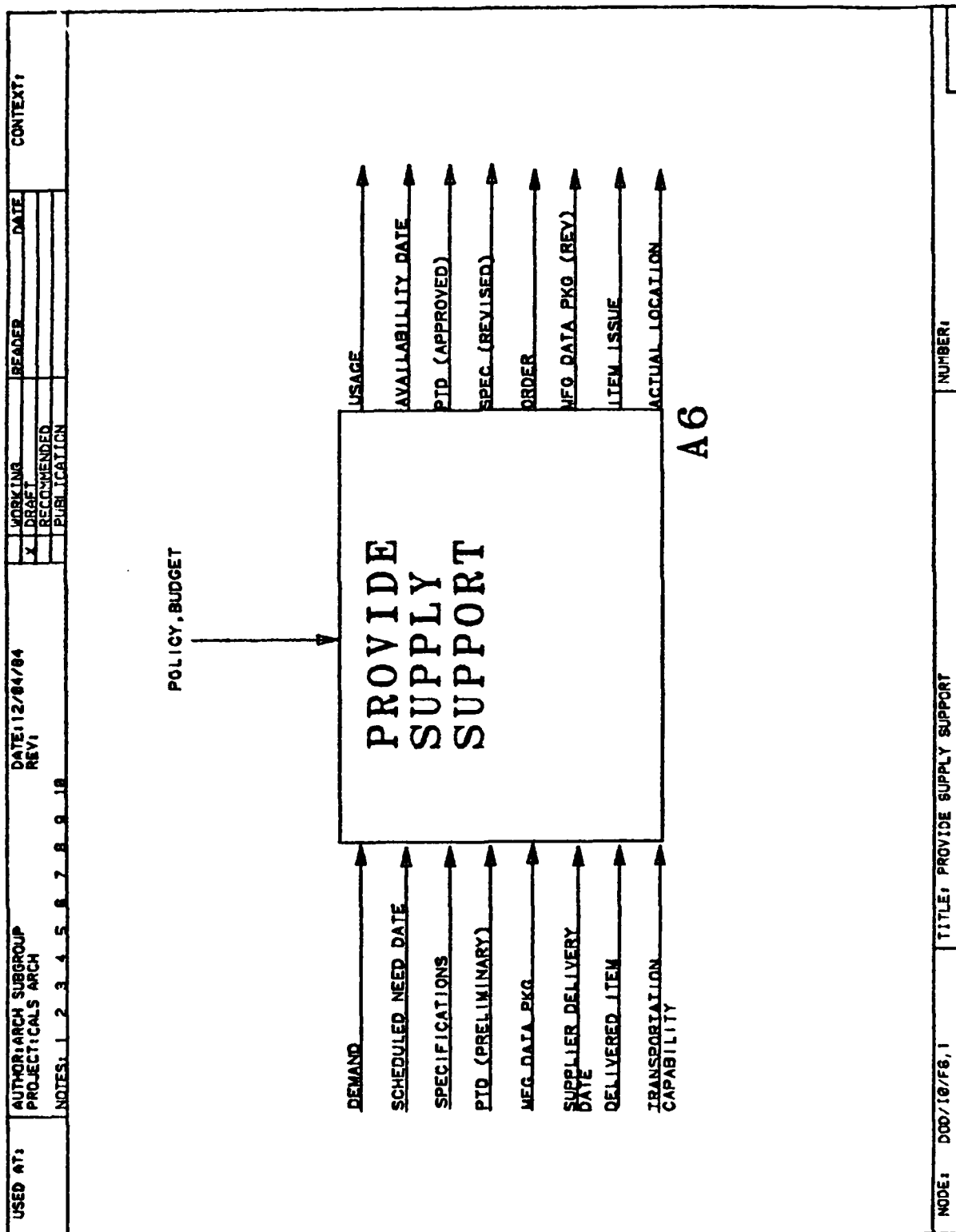


Figure 2-42. IDEF A6, PROVIDE SUPPLY SUPPORT, DOD

A6 Provide Supply Support

Glossary

Policy, Budget -

Demand - The recorded needs for an item of material.

Scheduled Need Date - The date on which an item(s) of inventory is required to be in place.

PTD - Provisioning Technical Data.

Usage - Recorded data on amount of use an equipment item receives.

Desired Location, Shelflife (PTD), Facilities - Assignment of location and storage requirements for an item of inventory.

Demand Schedule, Cost - The scheduled replenishment rate and estimated costs from which replenishment items can be acquired.

Availability Date - The data on which material will be available for shipment.

Replenishment Requirement - Material required to replenish existing stock or inventory item.

Spec - Specification for the replenishment item for purpose of procurement.

MFG Data Pkg - A set of information sufficient to manufacture the replenishment item.

Supplier Delivery Schedule - Contractor's schedule for delivery of material.

Cost & Delivery - Cost and delivery information feedback to inventory management's records.

Order - The process and data used to order material and services.

Delivered Item - Material item delivered from source of supply.

Transportation Capability - Definition of resources required to provide transportation of material.

Actual Location -

Item Issue -

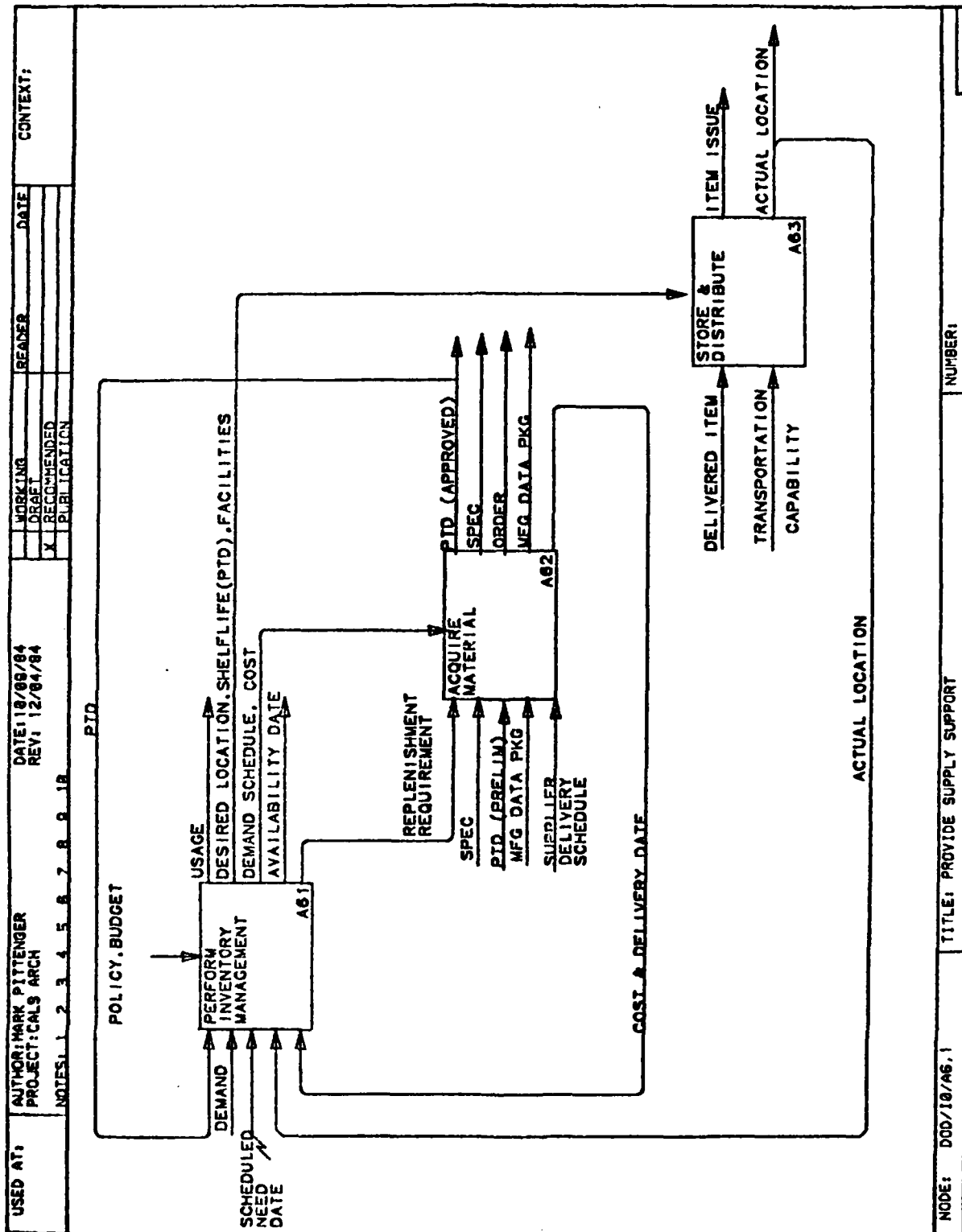


Figure 2-43. IDEF A6n, PROVIDE SUPPLY SUPPORT, DOP

IDEF A6 CONCEPT PAPER  
PROVIDING SUPPLY SUPPORT

1. FOCUS OF CALS IMPLEMENTATION

1.1 Projected Performance of the Target Computerized Functions.

The application of current and evolving computer technology, combined with the availability of CAD and CAM data, will revolutionize the traditional logistics activities of provisioning and supply. DoD provisioning and supply activities include the functions of provisioning technical documentation (PTD) acquisition, spare/repair part procurement/reprocurement, inventory management and storage/distribution. Provisioning and supply activities have traditionally been expensive, unwieldy and not particularly responsive to the needs of weapon system users, managers or manufacturers. The primary obstacle to resolving these difficulties has been the impossibility of creating, processing, disseminating and updating, in a timely manner, the mountains of data that are associated DoD provisioning and supply activities. With the advent of technologies that provide inexpensive data storage, improved data communication, network-wide operating systems and distributed data bases this no longer needs to be a constraining factor.

1.2 Implementation Considerations. The application of existing and developing computer technology to DoD provisioning and supply activities will significantly alter the manner in which they are performed, improve their cost-effectiveness and make them more responsive to the needs of weapon system users, managers and manufacturers. Although the means of accomplishment will be altered, very little new data will be required. Rather, the same data that are currently required will be needed in a different format or on a different media.

Though industry is capable, and in many cases has switched to automatic techniques and utilization of the LSAR for spares projection and listings, the Services have not yet accepted the techniques. Provisionings is still performed the "old way". No degree of improvement on the side of the contractor will engender an overall improvement until the Services modernize and actually use the automated techniques specified for the contractor's use.

**1.3 Likely Payoffs.** In the provisioning technical documentation arena, the application of these technologies will result in the streamlining and standardization of the preparation/submittal/review/approval process. The remaining paper flow associated with PTD activities will be replaced with exchanges of digital media and eventually with direct industry to DoD system communication. At the same time, the process that has been initiated with the development of MIL-STD-1388-2A will result in a standard industry-to-DoD provisioning data format for all DoD components. PTD efforts will increasingly be an integral part of the LSA/LSAR effort and will make extensive use of CAD/CAM parts list data. PTD screening activities will diminish in size and importance as data on parts presently in Government inventory (Defense Logistics Supply Center data) are made more readily available to industry and are integrated with CAE and CAD parts selection and standardization systems. Traditional illustrated parts breakdown manuals (IPBs) and repair parts and special tools lists (RPSTLs) will be replaced with on-line computer data bases that provide DoD personnel with all necessary data concerning appropriate spare and repair parts.

The spare/repair parts procurement function will also undergo significant changes. The present manual and semi-automated spares delivery tracking systems will be replaced with on-line systems that are regularly updated with information from industry systems. These updates will initially be performed utilizing data that are transferred utilizing removable computer media. Use of removable

media for data transfer will eventually be phased out and replaced with direct communication between DoD and industry computer systems. The present difficulties encountered with acquisition and maintenance of reprocurment data will be surmounted through implementation of a variety of improved capabilities and as a by-product of changes that are occurring in several other areas. Included among the improved capabilities are automation of DoD data repositories to allow improved retrieval of existing engineering data, procurement of new engineering data in computer sensible formats that are more accurate and easier to store, retrieve and update than paper media, and increased use of contractor data and personnel to facilitate identification of acceptable substitute and lower cost replacement items. Benefits will also accrue from changes that are occurring in the parts standardization area and as a result of industry movement to the use of CAE and CAD systems. Increased use of standard and existing inventory parts will decrease the volume data that must be acquired and maintained, while the movement to CAE and CAD systems will result in better designs that have fewer unique configurations and that require fewer retrofit and modification actions. The present "problem" of high cost spares and support equipment will disappear as weapon system designers make greater use of standard parts, DoD systems provide improved schedule and cost visibility to system managers and incentives are put in place for industry to design systems that minimize the need for expensive and unique spare parts.

The task of inventory management will be greatly streamlined. On-line inventory management systems will provide improved visibility of inventory status, consumption rates and locations. These systems will allow DoD personnel to spot developing support problems and initiate resupply and procurement actions in a timely manner. Improved visibility of inventory location will allow system managers to make the best use of available assets and to eliminate the problem of inadvertent



asset disposal. When coupled with improved feedback of field experience data, these systems will allow system managers to identify high-payoff areas for modification and/or redesign. Weapon system users and supply activities will benefit from implementation of these systems by being able to quickly locate needed items and obtain current information concerning on-order items.

The storage and distribution function will also change as a result of the application of computer technology. Input from the inventory management systems and feedback from analysis of field experience data will allow identification of such storage and distribution problems as inadequate quantity allocations, excessive shipping times and excessive shipping costs. In the same way, inventory costs will be reduced through timely identification and disposal of un-needed items and more effective management of calibrated and limited life components.

### **Annex 3**

#### **RECOMMENDED DEMONSTRATIONS**

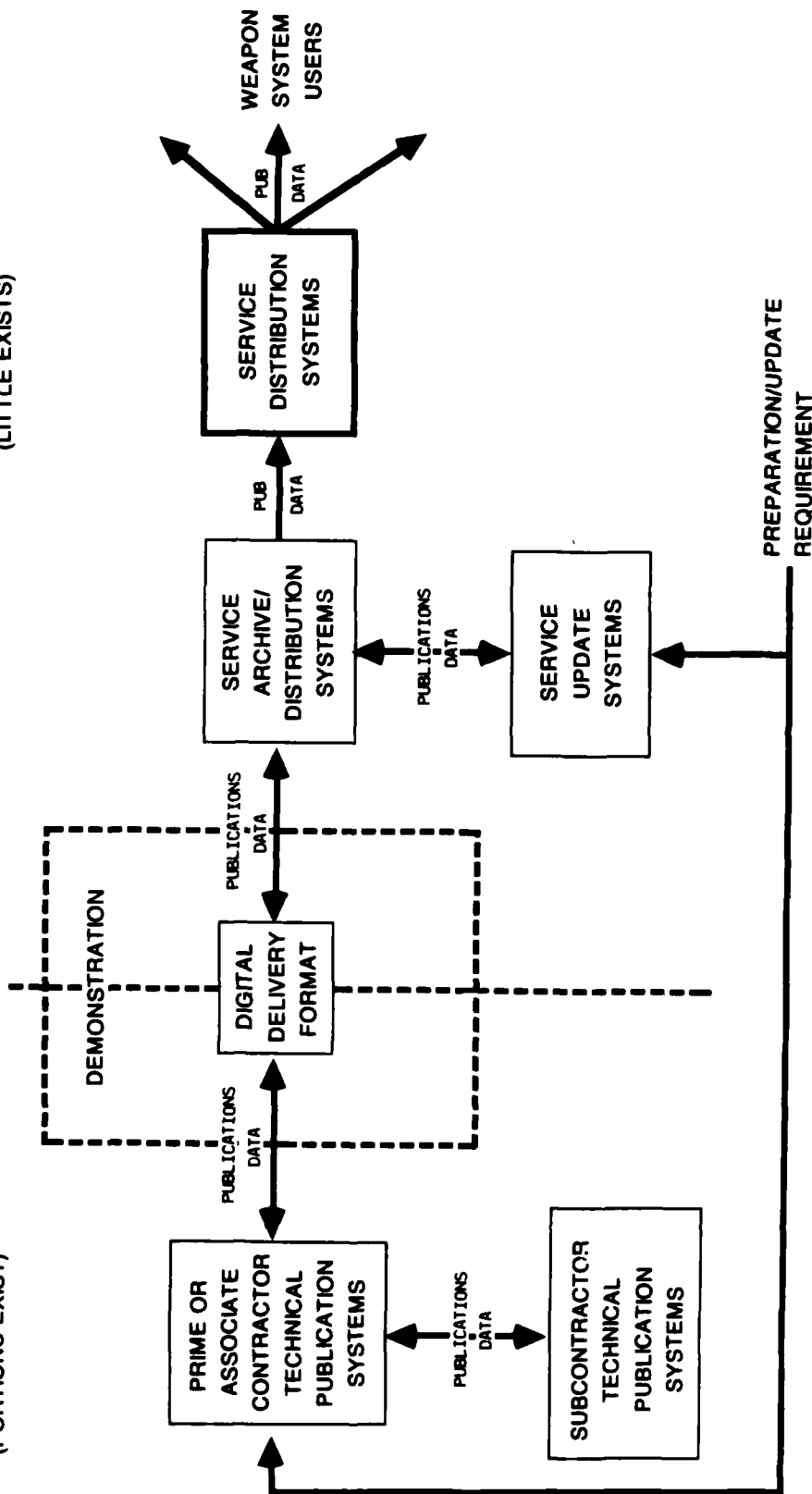
- #1 Digital Delivery of Technical Publications .....
- #2 Interactive Diagnostic and Maintenance Aids .....
- #3 RAMCAD .....
- #4 Automated LSAR Input .....
- #5 Automation of Classic Logistic Data Item .....
- #6 Computer-Aided Specification/RFP Preparation .....

## RECOMMENDED DEMONSTRATION #1

1. **Title:** Digital Delivery of Technical Publications
2. **Objective.** Develop and demonstrate a tri-Service capability to contractually specify and accept delivery of contractor developed technical publications in a digital format.
3. **Description.** As discussed in the CALS Concept Paper on preparation of maintenance and operation data, near-term improvement of the DoD technical publication system will be achieved through implementation of industry and DoD computing systems to aid the authoring, delivery, maintenance and distribution process. Such systems will be composed of three major elements, industry authoring systems, a computer-sensible deliverable data format and DoD/Service archive, update and delivery systems. Figure 4-1 presents a conceptual diagram of how such a system would operate. Of the three major near-term system elements, the most time critical is the development of the computer-sensible deliverable product. The reason for this is that both industry and the Services are currently planning and implementing computer systems to perform these functions. Without a standard data exchange format, industry systems that are oriented toward production of plate negatives will continue to be implemented and Service systems will each have their own unique data format. This will, in turn, require that each industry system have and maintain the capability to output to each Service system that will utilize its data. It will also require replacement or modification of much of the computing capabilities that are being put in place to produce plate negatives. Near term development and implementation of a computer-sensible deliverable data format is the most effective means available to guide the near-term development of government and industry computerized publication systems, ensure that these

INDUSTRY  
(PORTIONS EXIST)

SERVICES  
(LITTLE EXISTS)



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Figure 4-1. NEAR-TERM TECHNICAL PUBLICATIONS SYSTEM CONCEPTUAL DIAGRAM

systems can exchange data with each other, and minimize the total investment that must be made in these near-term capabilities.

Development of a computer-sensible deliverable data format should proceed as depicted in Figure 4-2. The following sections discuss each of the project elements. They are presented in the order that they should be performed.

a. Document Data Requirements. This task is needed to establish a firm baseline for evaluation and, if necessary, development of acceptable data exchange standards. The starting point for this effort would be the present technical publication specifications and standards. It is anticipated that this effort would draw heavily upon the Tri-Service Technical Manual Specifications and Standards (TMSS) consolidation effort that is currently in progress. The product of this task would be a concise statement of technical publication data requirements.

b. Survey Industry Systems and Plans. In order to minimize the cost of implementing a new data exchange format, it is necessary to develop an accurate picture of the current hardware and software base, and understand the direction of its evolution. The project's second task is, therefore, to conduct a comprehensive survey of current industry systems and future plans. The product of this task would be a document describing current industry computerized publication systems and the direction that they are evolving.

c. Survey of Service Systems and Plans. Just as with industry, a comprehensive understanding of current Service activities must be developed in order to minimize costs. The third project task is, therefore, to survey current and planned service technical publication computerization efforts. The product of this task would be a document describing current and planned service computerized publication systems and the direction of their evolution.

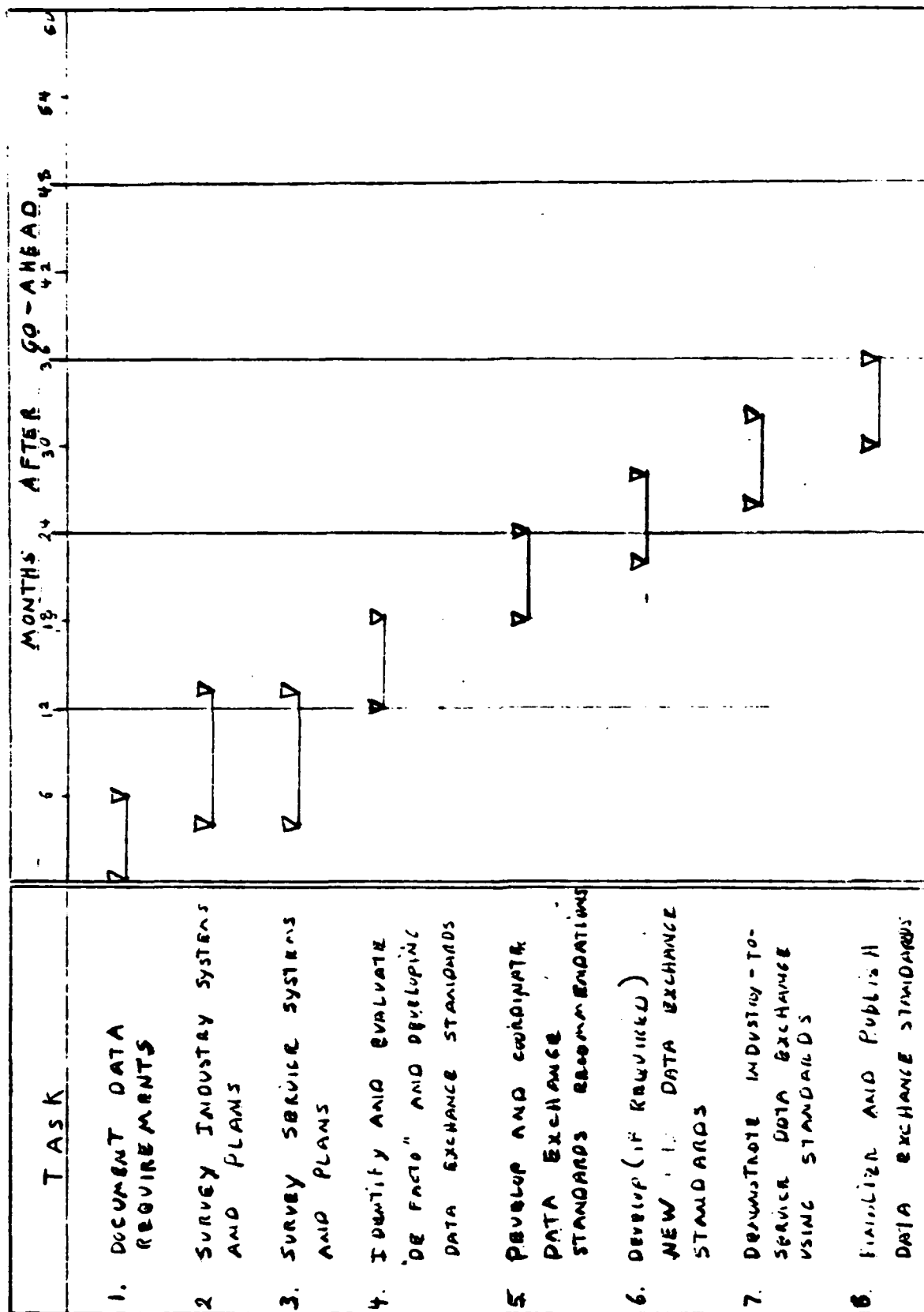


Figure 4-2. DIGITAL DELIVERY OF TECHNICAL PUBLICATIONS DEMONSTRATION PROJECT SCHEDULE

d. Identification and Evaluation of "de facto" and Evolving Standards. Prior to developing new data exchange standards, consideration should be first given to the possibility of adopting existing de facto or evolving data exchange standards. Accordingly, the fourth project task is to identify and evaluate these type of standards. The most often mentioned de facto standards in this area are the National Bureau of Standards IGES and Graphic Communications Association's GENCODE efforts. The product of this task would be a determination of the practicality of utilizing existing or evolving standards for the transfer of computerized technical publication data.

e. Develop and Coordinate Data Exchange Standards Recommendations. Completion of the first four project tasks provides the basis for accomplishment of task five, development of data exchange standards recommendations. These recommendations would be developed by evaluating the impact of standards deemed suitable under task four on current industry and Service efforts. Where the impact is too great, suitable standards do not exist, or modifications are needed, recommendations would be made concerning appropriate modification/development efforts. These recommendations would then be coordinated with the appropriate industry associations and Service agencies. The product of this task would be definitive recommendations concerning adoption of existing standards, needed changes to existing standards, and development of new standards.

f. Develop (if required) New Data Exchange Standards. Under task six, any development or modification effort recommended as a result of task (e) would be completed. The product of this task would be the completed data exchange standards and any software required to implement them (translators, validation routines, etc.)

**g. Demonstrate Industry-to-Service Data Exchange Using the Recommended Standards.** Task (g) would demonstrate the use of the recommended data exchange standards to exchange technical publication data between industry and Service systems. In order to provide a high degree of confidence in their usability, data exchanges would be performed between multiple industry and service systems, and would be performed in both directions.

**h. Finalize and Publish Data Exchange Standards.** Task (h) would be to finalize, document and publish the formal data exchange standards. The product of this effort would be a comprehensive set of data exchange standards that could be contractually implemented.

**4. What's Needed To Do It?** Three things are necessary to complete this project: (1) a DoD level decision to conduct it, (2) an appropriately chartered and funded organization, and (3) the support of industry and the Services. The first two items require action on the part of DoD. Industry support of the third would not be difficult to secure due to the high level of current interest. Tri-Service support has traditionally been difficult to obtain and would require some firm DoD direction.

**5. What Exists Today?** A significant investment has already been made by industry in computer hardware and software for development and production of technical publications. These systems generally include the elements of text entry, graphics creation, composition and negative production. In addition, most companies have plans in place for upgrade and enhancement of these systems. Also, there is currently considerable activity within the various industry associations relative to development of computer sensible data exchange standards. Of particular importance to this project are the ATA and NSIA efforts.



Each of the Services also has ongoing efforts that are related to this project. Of particular interest are the Air Force Automated Technical Order System (ATOS), the Navy Print on Demand (NPOD) and the Army Technical Manual Specifications and Standards (TMSS) projects.

6. What Does It Take To Get Started. The only effort required to initiate this project is to charter and fund an organization to conduct it.

## RECOMMENDED DEMONSTRATION #2

1. **Title:** Interactive Diagnostic and Maintenance Aids
2. **Objective.** To demonstrate the design of automated technical data for diagnostics and built-in sensors/test as a single integrated system.

The diagnostics testing capability built into the system and the diagnostic testing capability built into automated technical data (maintenance aids) are two aspects of the same diagnostic function. They require a common analysis, common man-machine design tradeoffs, and integrated design to assure compatibility and effective troubleshooting capability. This is increasingly important with the new generation of gracefully degrading avionics operating off a common data bus. Information for the technician's decision to repair or defer, and the repair instructions if a repair is called for, should be automatically shown on the automated tech data display. This should be drawn from the system state analysis in the on-board computer. If the on-board analysis is ambiguous, the technician should be able to use auxiliary troubleshooting aids in the automated technical data to stimulate and test the on-board system interactively. Unanticipated failure modes or outcomes should be fed back to engineering data management for rapid update of the diagnostic software in the automated technical data display. Such an integrated system will permit more effective troubleshooting and reduce false removals. This is essential to move toward two level maintenance concepts.

3. **Description.** The AFHRL Integrated Maintenance Information System (IMIS) diagnostics program, outlined in this paper, will develop and evaluate the diagnostic portion of IMIS (see outlined

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COMPUTER AIDED LOGISTIC (U) INSTITUTE FOR DEFENSE  
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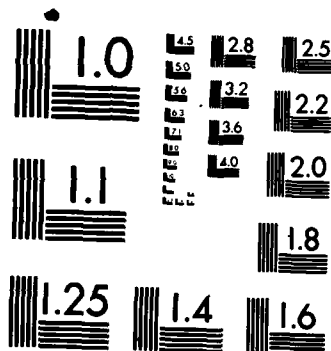
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MICROCOPY RESOLUTION TEST CHART  
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area of Figure 4-3) in conjunction with the Avionics Laboratory PAVE SPRINTER Demonstration Program. AFWAL/AA and AFHRL will jointly develop the diagnostic system which will consist of:

a. The portable computer (PCMAS) containing technical order instructions, troubleshooting aids, historical and other maintenance data.

b. An interface panel on the side of the aircraft, allowing the technician easy access to on-board information.

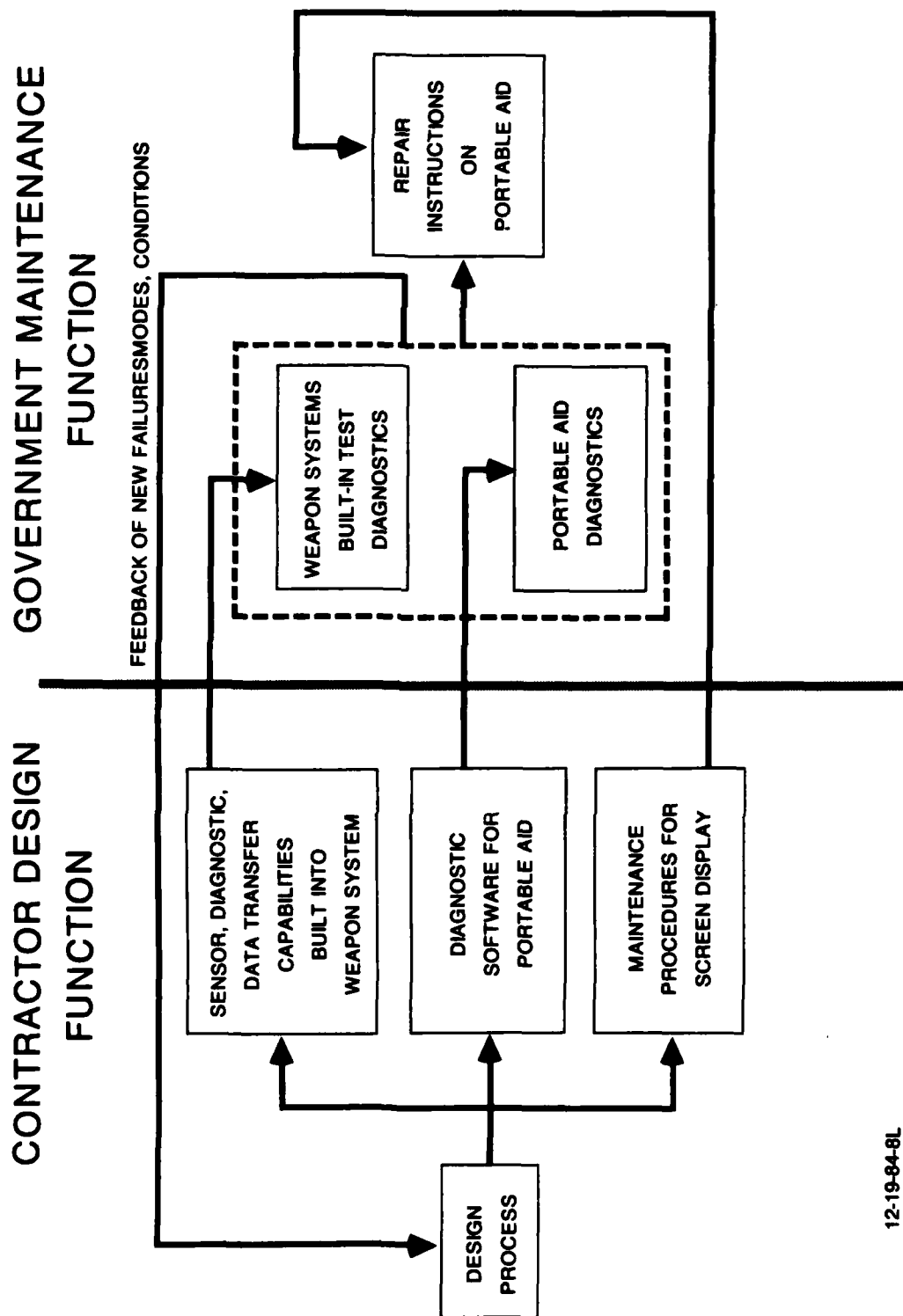
c. The interface hardware and software necessary for the portable computer to communicate with on-board systems.

d. The diagnostic software needed to integrate the on-board information with technical data, stand alone diagnostic routines, and historical flight parameter data.

**4. Necessary Programs.** The diagnostic system will be developed in two parts. The portable computer will be developed by enhancing the current design requirements for the PCMAS contract. The aircraft interface and diagnostic software will be developed by adding an additional task to the current PAVE SPRINTER contract. At the end of the PCMAS development, the portable computer and associated software will be provided as GFE to the PAVE SPRINTER contractor for integration in to the PAVE SPRINTER flight test.

The current PCMAS will be developed to display technical order and battle damage assessment data. The contract, which is planned to begin in Dec. 84, will be enhanced to include the capabilities needed for the IMIS diagnostics effort. The design requirements for the portable computer will be expanded to include the aircraft interface hardware/software, and any additional hardware/software needed to provide the processing capability to run the diagnostic software. The contract will be expanded to produce additional units of the portable computer, and to require the contractor to interface with the PAVE SPRINTER contractor.

# DIAGNOSTICS AND MAINTENANCE AIDES FLOW CHART



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Figure 4-3. DIAGNOSTICS AND MAINTENANCE AIDES FLOW CHART

The PAVE SPRINTER contract will be expanded to include the analysis, design, development, and evaluation of the integrated IMIS/PAVE SPRINTER diagnostic system. The major tasks include the following:

**a. Analysis**

- (1) Potential Diagnostic Technologies
- (2) Technician's Role in Diagnostics
- (3) Evaluation of PAVE SPRINTER Capabilities

**b. Design**

- (1) Definition of IMIS System
- (2) Develop Software Design and Interface Requirements
- (3) Conduct Man-Machine Interface Studies
- (4) Develop Test Plan

**c. Development**

- (1) Develop Software
- (2) Construct Hardware Interface
- (3) Develop Technical Data and Diagnostic Data
- (4) Lab Integration Test

**d. Flight Demo**

- (1) Prepare and Support Flight Test
- (2) Validation of Diagnostic Techniques
- (3) Validation of Man-Machine Interface

**e. Report and Draft Specifications**

**5. Milestones.** See Figure 4-4.

	1985	1986	1987	1988
PORTABLE COMPUTER	▲—————▲			
PAVE SPRINTER INTEGRATION	▲—————▲			
GROUND-BASED LAB TEST OF INTEGRATED SYSTEM				▲—————▲
FLIGHT TEST DEMONSTRATION				▲

Figure 4-4. INTERACTIVE DIAGNOSTIC AND MAINTENANCE AIDS,  
DEMONSTRATION SCHEDULE



### RECOMMENDED DEMONSTRATION #3

1. **Title:** Reliability and Maintainability in Computer-Aided Design (RAMCAD)

2. **Objective.** Demonstrate and document the benefits of integrating R&M analysis into computer aided engineering and design systems. A comprehensive capability to do CAD-based reliability and maintainability analyses needs to be developed and demonstrated. This will require a number of RAMCAD demonstrations to be conducted in several areas: the use of historical data to feed a CAD based R&M analysis; CAD-based predictions of MTBF, MTTR, etc., scenario simulations; etc. However, as important as each of these demonstrations are, the critical demonstration is one of integration. Several CAD-based RM&L analyses need to be pulled together and be applied on a single hardware program.

3. **Description.** The opportunity to significantly improve the ability of the defense industry to design for supportability exists because of the explosive emergence of Computer-Aided Design (CAD) as the standard procedure of American industry. One of the reasons for this rapid growth is that CAD greatly reduces the calendar time and engineering man-hours required to create a new design while simultaneously producing higher quality results. Productivity improvements of 4:1 and higher are often reported.

The defense industry is a world leader in the area of Computer-Aided Design. However, the use of CAD to address reliability, maintainability, and logistics is still its infancy. While there are isolated activities which are adapting R&M techniques for CAD, they are primarily IR&D programs and not yet part of the engineering mainstream.

The RAMCAD integration demonstration should take the best CAD-based RM&L analyses and latch these together into a single system. (This may require some adaptation of existing models and software.) This system should then be demonstrated on a hardware design (redesign) effort of moderate size. All RM&L analyses required to ensure a completely supportable design would be available through the RAMCAD (CALS) workstation. (See CALS equipment design influence write-up Section II.B. IDEF A2.) Given sufficient resources, this demonstration may be completed within three years.

These chief tasks facing the demonstration team will be these:

- a. To identify the models/analyses/packages to be integrated.
- b. To integrate them into one system available on a single CAE computer hardware/software configuration.
- c. To identify the hardware design/redesign effort to be used as a demonstration vehicle.
- d. To conduct the demonstration and document the results.

By appropriately structuring the demonstration, a number of difficulties may be avoided. For example, a comprehensive RAMCAD capability can be developed and demonstrated on a single CAE system (Computer-Vision, application, CADAM, etc.) without waiting for all the inter-system communication problems to be solved. This will greatly speed the development effort while reducing the risk.

4. **Benefit.** It is clear that we need to make quantum improvements in the supportability of our weapons systems if we are going to fulfill the objectives outlined by the Service plans for the year 2000. Just as 70 percent of life cycle costs of a weapon are set in early design, so too are the general support characteristics (down time, refueling time, spares required, etc.). By fully integrating R&M into CAD, RAMCAD will make ILS a true design function, giving it even effectiveness never before achieved. RAMCAD will allow us to design the required

supportability characteristics into the weapon systems up front. This will result in systems which are more reliable, more maintainable, and cheaper to operate.

In addition to bringing RM&L into early design, RAMCAD will allow far more accurate and complete analyses to be regularly performed. This is because CAD is very fast and enables engineers to develop and evaluate several configurations in the time it is used to accomplish one. Because design errors will be reduced in number and caught earlier, expensive redesign for logistics will be avoided, speeding the acquisition cycle and sharply reducing the time required to field truly supportable systems.

5. Related Activities. There are a number of activities directly related to conducting a RAMCAD demonstration. These include: AFHRL's maintenance and logistics factors in the Computer-Aided Design program which is conducting a series of demonstrations documenting the benefits associated with limited, isolated RAMCAD analyses; NCSC's Computer-Aided Engineering for testability, which is building testability tasks for integration into CAD; RADC's ORACLE developments; NSIA's MLCAD study group work, which is polling industry on commercially available RAMCAD models, the Army ECAM program, the IDA RAMCAD Specifications Study; and finally the JLC RAMCAD subpanel efforts. In addition to the above activities, most aerospace firms have limited IR&D efforts underway.

6. Implementation. The RAMCAD demonstration can be completed in three years. A single agency should be identified to manage the effort with sufficient resources to accomplish the task. This would include 4-5 people to manage it and 10-15 million over a 3-year period. This agency would then manage the effort, accelerating the existing Service efforts (above) and identifying an appropriate demonstration vehicle. Given the relative sophistication of CAE for electronics and the extensive work already accomplished in this area, an avionics system is

recommended for the initial demonstration focus. This would also allow a demonstration to be conducted that be would applicable across all three Services.

By leveraging efforts currently underway, the RAMCAD demonstration will greatly shorten the time required to conduct the demonstration, reduce the technical risk, and speed the benefits to be achieved from the high levels of system reliability, maintainability and availability which will be routinely achieved when RAMCAD is implemented across the broad in industry design procedure.

#### 7. Milestones.

Identify Implementation Agency	2Q FY 85
Identify Functions/Analyses to be Automated	4Q FY 85
Adaptation/Automation/Integration of Models	4Q FY 86
Identify Demo Vehicle	2Q FY 85
Demonstrate RAMCAD in Decision/Design of Demo Vehicle	1Q FY 87 - 4 FY 88

## RECOMMENDED DEMONSTRATION #4

1. **Title:** Automated LSAR Input

2. **Objective.** The objective of this demonstration is to develop and demonstrate the capability to automatically input data to the Logistic Support Analysis Record (LSAR). This capability will extract data from the CAD Engineering Data Base and other automated systems and load then directly into the LSAR.

3. **Background.** Today the LSAR (required by MIL-STD 1388-2A) is a highly labor intensive, cumbersome, unresponsive and expensive process. One of the objectives of MIL-STD-1388-2A is to ensure that support is properly considered in the design of new weapon systems. Unfortunately, because of the complexity of the design process and the movement toward specialization, this objective has never been completely realized. At most defense contractors, the LSAR is accomplished by logistics specialists completely removed from the design process in both time and space. As a result the LSAR is after the fact, has little or no effect on the design, and is viewed by many contractors as an unnecessary and expensive requirement.

In order to reduce the cost for the preparation of LSARs, many contractors have invested in an automated LSAR software. This has allowed them to automate much of the records keeping and do limited analyses, with sophisticated LSARs. However, even in the best circumstances, the information is input manually through a keyboard.

Paralleling this movement toward automated LSARs has been a very rapid growth in the automation of design and manufacturing processes. Most defense contractors do a significant portion of

their new design using computer-aided engineering methods. Some companies do all of their new designs using CAE and many expect to do so in the very near future. This has had a number of results:

- o Because they are not yet hooked into the CAE environment, the logistics specialists completing the LSAR do not have access to the latest configuration to analyze.
- o Often the logistics specialists duplicate analyses (reliability, maintainability) which were previously done by the design, reliability or maintainability engineers during the part's design phase.
- o The increased productivity of the design engineer using CAE puts the logistics specialist farther behind the curve in terms of influencing the design.
- o In the most automated companies logistics specialists are literally taking data from one automated system (CAE) and manually keying them into another (the automated LSAR).

The demonstration is aimed at addressing each of these issues, thereby streamlining this expensive process, reducing errors, and eliminating duplication of effort, making it less expensive, faster, more responsive, and ultimately, through the use of CAE, a true part of the design process.

3. Description. The automated LSAR input demonstration will take information directly from the CAE data base and enter it into the LSAR without human intervention. Once this interface is successfully demonstrated, the next step is to reverse the flow of information so that the LSAR information is available to do comparability analysis via CAD. Next, an assessment of the usefulness of the automated input to the LSAR will be required.

The demonstration should take a specific automated LSAR and interface it directly with a specific CAE workstation that will form a fundamental part of the CALS workstation and, as such, should be fully cognizant of the relevant standards and protocols. However, the ability to interface directly with CAE because of its importance, should be demonstrated completely before integration into the CALS workstation occurs.

4. **Implementation.** There are a number of related activities. Each major defense company has some automated LSAR and at least one CAE system. Some companies have begun to work through the problem of interfacing LSAR with CAE. The Air Force has begun a study to look at interfacing their automated LSAR (the Unified Data Base for Logistics Information) with a CAE workstation. These activities should be accelerated and this demonstration should be initiated. It could be accomplished within 3 years for a cost of \$3 million.

5. **Milestones.**

Select a Automated LSAR	3 Qtr 85
Select a CAE system	3 Qtr 85
Define Interface	2 Qtr 86
Implement Interface	2 Qtr 87
Demonstrate Linkage	4 Qtr 87
Demonstrate and Document	
Benefits	3 Qtr 88

## RECOMMENDED DEMONSTRATION #5

1. **Title:** Automation of Classic Logistic Data Item

2. **Objective.** The demonstration will employ computerized techniques to prepare a classic logistic data item (i.e., Support Equipment Recommendation Summary) in its presently specified format directly from an LSAR data base. This will bridge the gap between near term and future data acceptance, while at the same time demonstrating that all duplication of effort between LSAR and the additional data items that are duplicative, but yet still required by data users, can be eliminated.

3. **Description.** Users of classic data items are accustomed to the format that has been specified over the years. Therefore, they still glean the information necessary for their use from a structured format with which they are intimately familiar. The format, in turn, is merely an arrangement of technical data and information which is mostly derived from design information, and with which the contractor is also familiar. The LSAR specifications, namely MIL-STD-1388-1A and -2A, have defined a disciplined way to collect and label the data fields that are necessary for logistics resource planning and acquisition. Normally the contractor prepares the classic data items in parallel with, or sometimes even ahead of, LSAR preparation. The classic data items are still being used for the actual resource planning and acquisition, rather than the LSAR. It stands to reason that if the elemental data fields would serve the purpose for input to the LSAR, as well as input to the preparation of the classic data items, that the LSAR data base could be used to prepare the data items.

If that assumption is true, then the automation of the LSAR, as it exists today for its own internal data sorting into output summary reports, could very well be modified to automatically



prepare the classic data items. In turn, having demonstrated that, the next logical step could very well be that the data item could be eliminated completely, and the users of that data could interrogate the LSAR data base directly for input into their decision making process. This of course would save the expense and manpower demands for data item preparation as well as the preparation of LSAR output summary reports and their subsequent translation.

To provide credibility that this would work, the experiment would need a control. The control could simply be the preparation of the candidate data item by the classical manual means. The resulting outputs could then be compared and should prove to be identical.

The demonstration would start by preparing the data fields for the candidate item in precisely the same manner as if inputting to the LSAR. Since automatic LSAR inputting is not a necessary part of this experiment, manual collection and inputting of these data would be acceptable. However, the LSAR would have to be able to transform these data automatically into the presently specified -2A structure. Once in the data base, the data base would be interrogated by a combination of data base management, analytical, and text-processing-type programs which will rearrange the raw data contained in the LSAR data base into the data fields required by the data item. Summarization and analyses, if necessary, will be also handled by that program. The demonstration will continue with proving that the data so collected and structured can be traced to the configuration of the item that they represents, either by the LSAR numbering system, or by some other scheme yet to be defined. Ease of updating and archiving, beyond that available with paper data, must also be demonstrated.

#### **4. Implementation**

**4.1 Technical Requirements.** The technical requirements for this demonstration could range from relatively simple to very complicated, depending on the data item that is chosen. A data item that needs only rearrangement and minor calculations, such as a Support Equipment Requirements Document, will not require complex or expensive computer techniques to accomplish the demonstration. On the other hand, a data item such as a Calibration Requirements Summary would be much more difficult, and expensive to demonstrate. For the simpler case, an automated LSAR program such as the UDB will be required. As mentioned previously, normal manual inputting would suffice for the purposes of this experiment, although of course automatic inputting would be of still greater value. The data base manager which will extract the information from the LSAR data base will need to be designed, as will the interaction with the text processor, and whatever analytical techniques are deemed necessary. This, however, is not beyond the state of the present computer techniques available commercially, especially in the personal computer industry.

**4.2 Available Material.** There are several automatic LSAR preparation procedures available. The Air Force's UDB used on the B-1 program is just one of these. There are also independent industry efforts available for the automatic data preparation of some limited, simple data items. These, however, do not use the LSAR data base to do this, but rather use the inputs which are normally derived from engineering information. However, these programs can help in structuring the data preparation software system to interact with the data base manager and text processor.

**4.3 Required Resources.** The demonstration would be rather simple to get underway. Contractors who are presently using an LSAR data base system would be solicited to (a) provide

suggestions as to which data item would prove a good candidate, as well as (b) what hardware item(s) would be most feasible to perform the demonstration on, to provide a good cross section of support equipment types. These contractors could then be asked to quote the demonstration. Therefore, only financial resources are really necessary.

5. Milestones.

Identify Implementing Agency	3Q FY 85
Solicit Contractor to Provide Suggestions	3Q FY 85
Select Hardware System	3Q FY 85
Select Data Item	3Q FY 85
Prepare Computer Programs	2Q FY 86
Prepare Data Item	1Q FY 87

## RECOMMENDED DEMONSTRATION #6

1. **Title:** Computer Aided Specification/RFP Preparation
2. **Objective.** To demonstrate that reliability, maintainability and supportability equipment design attributes can be developed as part of a specification's performance requirements by computer interaction with, and prompting of, the authors. The specification would, as part of an RFP, be sufficiently specific that the appropriate design features would be provided by the designer, taking advantage of the competitive leverage during the proposal phase.
3. **Description.** The demonstration would be limited to one or two aspects of reliability and maintainability issues that are design driven. Demonstration would also be limited to a reasonably small subsystem so that the required initial programming would not be overwhelming. It is suggested that the attributes of reliability's mean time between failures and maintainability's built-in-test be selected as the candidates, because of their importance to readiness and sustainability. Unlike other programs available today which assemble information from a library of "canned" statements, this program would develop statements by interaction with the government's systems or equipment engineer as he prepares the performance specification requirements.

The result would give an entirely new look to the reliability and maintainability contents of a specification, in that the "real" requirements would become part of the performance requirements in Section 3 of a specification. Statistical figures of merits, if they are really needed, could then be developed from these statements to be included into the RFP's reliability and maintainability sections.

As an example, assuming that a radar set is being specified, and that the aircraft sortie rate and minimum required turn around time have been established by the user, along with the mission profile requirements for that radar, the following kind of interactive prompting would result in specification statements that the design engineer must address as part of his design rather than the customary design, analyze, rearrange the apportionments, try it again, etc.

The engineer may prepare a statement such as: "minimum target cross section shall be two feet, at a maximum range of ten miles". He may then be asked by the program: "if this requirement is not met during a mission, what would you like to see happen", and give him a menu to choose from:

- a. Depends on how bad it is.
- b. Warn pilot, with:
  - (1) Alarm
  - (2) Alert lamp
  - (3) Status panel
  - (4) Switch to redundant radar

If he should have answered (a), another set of prompts would come up immediately: "In these statements you have made, what is the worst that you could live with during the heat of a battle?":

- a. If that threshold is reached what should take place?:
  - (1) Alarm
  - (2) Alert lamp
  - (3) Status panel
  - (4) Switch to redundant radar
- b. Performance has degenerated beyond that threshold to (specify the degree), what should happen?:
  - (1) Alarm
  - (2) Alert lamp

- (3) Status panel
- (4) Switch to redundant radar

c. If the threshold has been crossed beyond (b), what should happen?:

- (1) Alarm
- (2) Alert lamp
- (3) Status panel
- (4) Switch to redundant radar

Another question which might help him make the decision regarding what he should put into the answers could be: "is the target?":

a. Life threatening.

b. Is countermeasures possible within \_\_\_\_ seconds of closing, (here the program could check the tolerances given on the range from knowledge of the missiles and the aircraft which have been input prior to starting this session, and feed this back to the engineer so that he may adjust his answers).

c. Not life threatening but mission essential.

d. Neither life threatening nor mission essential.

If he answered (c) or (d) the prompts could ask him to reconsider his previous answers, if they reflect a potential overkill by the engineer.

All this would define what self-test and self-healing features the designer must include to provide specified action.

Reliability related interrogations could be questions such as: "is the appearance of the target under the pilot's control?", Yes or No. If the question was answered "Yes", then: "is mission workaround possible?", Yes, No, Not Essential.

From knowledge of the mission duration, whether this was a missile or not, and from previous answers, the program could now compute serial and parallel reliability figures of merits for the

performance function, which in this case was target cross section recognition capability.

To respond to this (in the proposal or design), it would be up to the design engineer to consult with the reliability engineer as to the apportionment of the failure rates to the circuit components which are planned for use. In this way there would be no doubt that that particular function has been addressed as a required performance function, and not merely as a part of a pool of failures, which may have nothing to do with that function.

The data collected by the program from this interrogation can then be handled in several ways (the handling would depend on how sophisticated a technique is desired to be demonstrated). The simplest would be to feed that information back to the engineer-author so that he could structure it into statements which will be included as subparagraphs to the particular performance requirement; or the program could search a library of "canned" phrases to which the information gleaned from the various responses is added, so that actual sentences or subparagraphs are generated by that program.

#### 4. Implementation

4.1 Technical Requirements. Having chosen a candidate system, a typical performance specification for such a system would be researched by a team consisting of a design engineer, reliability engineer, and maintainability engineer, who would prepare appropriate questions similar to those above, which would be used by a programmer to develop the interactive program. If the candidate specification were relatively simple as concerns technical requirements, then a small computer such as an IBM PC would suffice to conduct the experiment. Therefore, a computer and printer and the four professional talents previously mentioned are all that will be required to develop the input. The resultant specification however,

should be tested by a different team consisting of a design engineer, reliability engineer, and maintainability engineer, for an independent assessment of understanding and acceptability.

**4.2 Existing Technologies/Developments.** Presently there are on-going programs for authoring specifications. However, these are not interactive programs, in the sense that they would interact with the illities to prepare the performance requirements. Rather they are mind-joggers and pat-phrase assembly type of programs, to take "canned" statements, ask the author to modify them slightly and then assemble a specification from that. This type of program would be helpful in the final assembling of the specification to be demonstrated. Interactive programs also exist for different applications in the private sector, such as the ELISA program, which is an interactive game. The techniques used in that program are precisely what are needed here for interaction. Another existing program, and there are many of these in the private sector, is the program called Think Tank. This is a data base program that is able to expand and collapse notes in such a way that they can be assembled into any final document. The program allows rearranging, ordering of priorities, etc. This type of program would be very helpful also. In all, there are examples of such programs in different applications available today. Therefore, the programming technique need not be invented, rather an application of existing techniques is all that is necessary.

**4.3 Getting Started.** This entire demonstration could well be conducted by the Air Force's Human Resources Lab, since the required skills for preparation of a specification in the area of performance, reliability and maintainability exists. Therefore, the starting process only requires tasking statements and budgets. The review of the output should really be conducted by industry. To do that a contract would have to be prepared, and funding made available. A better alternative, which would avoid



the contracting issues, would be to engage IDA in that study entirely, since both the Services and industry representatives are available to IDA.

5. Milestones.

5.1 Identify Implementing Agency	3Q FY 85
Select a Sample Portion of a Specification	3Q FY 85
Solicit Contractor to Quote the Requirement	4Q FY 85
Design the Program	4Q FY 86
Run Sample	4Q FY 86
Analyze Results and Prepare Report	1Q FY 87

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